DAQ

NI SCB-68A User Manual

68-Pin Shielded Connector Block

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The following conventions are used in this manual:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, AO <3..0>.
»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **Options»Settings»General** directs you to pull down the **Options** menu, select the **Settings** item, and select **General** from the last dialog box.
	This icon denotes a tip, which alerts you to advisory information.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on a product, refer to the *Read Me First: Safety and Electromagnetic Compatibility* document for information about precautions to take.
bold	Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.
italic	Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

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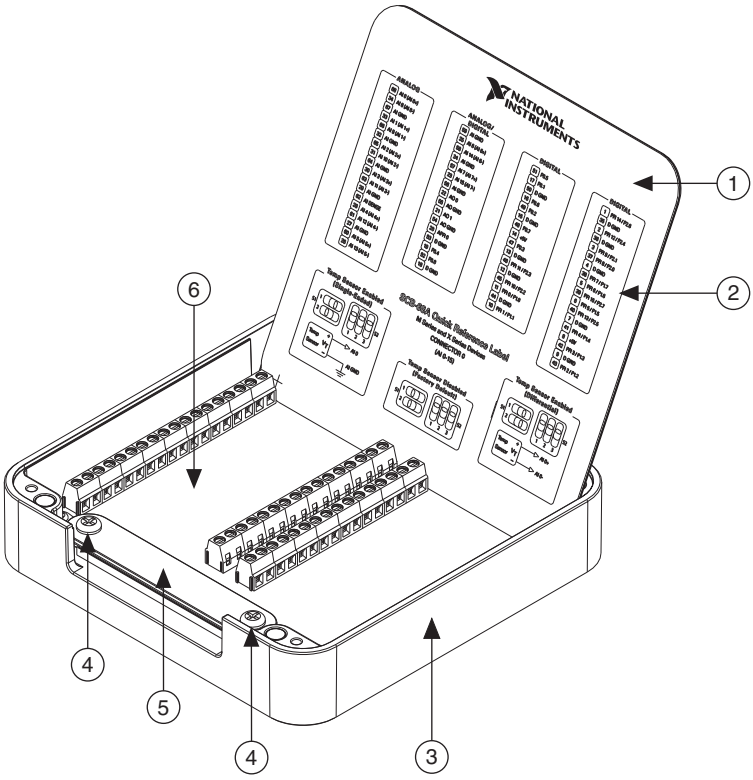
1

Getting Started with the SCB-68A

The SCB-68A, shown in Figure 1-1, is a shielded I/O connector block with 68 screw terminals for easy signal connection to a National Instruments 68-pin or 100-pin DAQ device.

Figure 1-1. SCB-68A Parts Locator Diagram



1	Top Cover (Required)	4	Strain-Relief Screws
2	Quick Reference Label	5	Strain-Relief Bar
3	Enclosure Base	6	SCB-68A Board Assembly

The SCB-68A features a general breadboard area for custom circuitry and through hole pads for interchanging electrical components. These through hole pads allow filtering, 4 to 20 mA

current input measurement, open thermocouple detection, and voltage attenuation. The open component pads allow you to easily add signal conditioning to the analog input (AI), analog output (AO), and PFI 0 signals of a 68-pin or 100-pin DAQ device.

This chapter describes how to connect and use the NI SCB-68A with 68-pin or 100-pin data acquisition (DAQ) devices and other NI products with a 68-pin SCSI or VHDCI I/O connector. For a complete list of supported devices and available SCB-68A features, refer to the KnowledgeBase document, *Compatible Devices and Cabling for the NI SCB-68/SCB-68A Terminal Block*. To access this document, go to `ni.com/info` and enter the Info Code `scb68Acables`.

Note To use the SCB-68A with devices without analog input functionality, as well as R Series, AO Series, and DIO/TIO Series devices, you *must* use direct feedthrough mode, you *must* change the default switch setting. Refer to the *Using the SCB-68A in Direct Feedthrough Mode* section for more information.

What You Need to Get Started

To set up and use your SCB-68A, you need the following:

- ☐ SCB-68A 68-pin shielded connector block kit(s)[1], containing the SCB-68A and *SCB-68A Quick Start*
- ☐ Compatible 68-pin or 100-pin DAQ device, and device documentation
- ☐ The correct cable(s) for your device, as listed in the KnowledgeBase document, *Compatible Devices and Cabling for the NI SCB-68/SCB-68A Terminal Block*. To access this document, go to `ni.com/info` and enter the Info Code `scb68acables`.
- ☐ For those not using M/X Series Connector 0, the correct quick reference label or PDF for your device, which you can find in the KnowledgeBase document, *Where Can I Find NI SCB-68A Quick Reference Labels?*. To access this KnowledgeBase, go to `ni.com/info` and enter the Info Code `scb68alabels`.
- ☐ #2 Phillips screwdriver
- ☐ 0.125 in. flathead screwdriver
- ☐ 14–30 AWG wire
- ☐ Wire cutters
- ☐ Wire insulation stripper

[1] You can use up to two SCB-68A accessories with AO/M/X Series devices with two connectors and E Series 100-pin devices. You can use up to four SCB-68A accessories with R Series devices with four connectors, and up to three SCB-68A accessories with R Series devices with three connectors.

Setting up the SCB-68A

The following cautions contain important safety information concerning hazardous voltages and connector blocks.

Safety Cautions Do *not* connect hazardous voltages (>30 V_{rms}/42 V_{pk}/60 VDC). Refer to your device documentation for information about the electrical limits of your device.

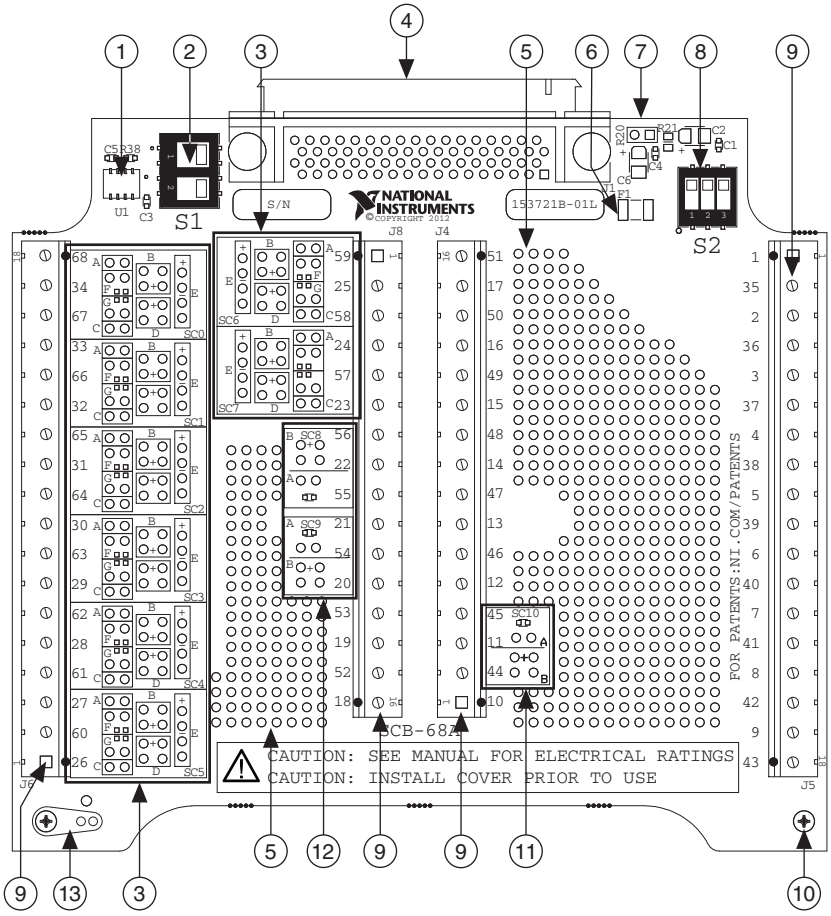
Install cover prior to use. To avoid electrical shock, do *not* remove SCB-68A covers unless you are qualified to do so. Before removing the cover, disconnect any live circuit from the connector block. Replace cover for use.

The chassis ground lug on your SCB-68A is for grounding high-impedance sources, such as a floating source (1 mA maximum). Do *not* use the chassis ground lug as a safety earth ground.

EMC Caution To ensure the specified EMC performance, operate this product only with shielded cables.

Figure 1-2 shows the SCB-68A PCB parts locator diagram.

Figure 1-2. SCB-68A Printed Circuit Board Diagram



1	Temperature Sensor	8	Switches S2.1, S2.2, and S2.3
2	Switches S1.1 and S1.2	9	Screw Terminals
3	Analog Input Pads	10	Printed Circuit Board Mount Screw
4	68-Pin I/O Connector	11	PFI 0 Pads
5	Breadboard Area	12	Analog Output Pads
6	1 A Self-Resetting Fuse	13	Printed Circuit Board Mount Screw and Chassis Ground Lug
7	+5 V Power Pads, R20 and R21		

Note If the kit is missing any of the components in Figure 1-2, contact NI.

To get started with the SCB-68A, complete the following steps while referring to Figures 1-1 and 1-2. If you have not already installed your DAQ device, refer to the installation guide that came with your DAQ device for instructions. Remove all cables from the SCB-68A before getting started.

1. (Optional) Mount the SCB-68A to a panel or DIN rail, as described in the *Mounting the SCB-68A* section.
2. Remove the cover.
3. Remove the film from both sides of the cover.
4. (Optional) If you are not using the SCB-68A with Connector 0 of an M/X Series device, attach the quick reference label to the inside of the cover as shown in Figure 1-1. For quick reference label PDFs for most compatible devices, refer to the KnowledgeBase document, *Where Can I Find NI SCB-68A Quick Reference Labels?*. To access this KnowledgeBase, go to `ni.com/info` and enter the Info Code `scb68alabels`.

Tip You can *stand* the cover in the SCB-68A for easy reference, as shown in Figure 1-1.

5. Configure switches for the signal types you are using, as explained in the *Using the SCB-68A in Direct Feedthrough Mode* section or the *Using the SCB-68A with MIO DAQ Devices* section.
6. Adjust the strain-relief bar by removing the strain-relief screws with a #2 Phillips screwdriver.
7. Connect the wires to the screw terminals by stripping 6 mm (0.25 in.) of insulation, inserting the wires into the screw terminals, and securely tightening the screws with the flathead screwdriver to a torque of 0.5–0.6 N · m (4–5 in. · lb).

Caution To ensure the specified EMC performance, signal wires routed outside of the enclosure *must* be contained within a shielded cable and connected to shielded accessories. Cable shields must be terminated to the chassis ground lug using as short a connection as is practical.

8. Reinstall the strain-relief (if removed) and tighten the strain-relief screws. If the shielded cable is too large to route through the strain-relief hardware, either use multiple, smaller-diameter cables or remove the top strain-relief bar and add insulation or padding if necessary to constrain the cable.
9. Replace the cover.

Caution You must install cover prior to use.

Caution Do *not* connect input voltages >30 V_{rms}/42 V_{pk}/60 VDC to the SCB-68A. The SCB-68A is not designed for any input voltages >30 V_{rms}/42 V_{pk}/60 VDC, even if a user-installed voltage divider reduces the voltage to within the input range of the DAQ device. Input voltages >30 V_{rms}/42 V_{pk}/60 VDC can damage the SCB-68A, all devices connected to it, and the host computer.

Caution Do *not* use for measurements within Categories II, III, or IV.

10. Connect the SCB-68A(s) to the DAQ device using the appropriate cable(s) for your device. For a complete list of cabling options for supported devices, refer to the KnowledgeBase document, *Compatible Devices and Cabling for the NI SCB-68/SCB-68A Terminal Block*. To access this document, go to `ni.com/info` and enter the Info Code `scb68acables`.
11. Launch Measurement & Automation Explorer (MAX), in the left panel, expand **Devices and Interfaces** to confirm that your DAQ device is recognized, and then configure your device settings.
12. (Optional) To take measurements with an MIO DAQ device, configure the SCB-68A as an accessory for a DAQ device by completing the following steps.
    a. In MAX, right-click your DAQ device and select **Configure**.
    b. On the **Accessory** tab, select **SCB-68A** from the pull-down menu and select **Configure**.[1]
    c. In the Accessory Configuration window, enable or disable the temperature reference sensor and click **OK**.
    d. Click **OK**.

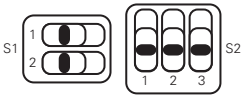
    For more information about configuring the SCB-68A for a DAQ device, refer to the *Measurement & Automation Explorer Help for NI-DAQmx*.
13. Test specific device functionality. Run a Test Panel in MAX by right-clicking your DAQ device and selecting **Test Panels**. Click **Start** to test the device functions.

When you have finished using the SCB-68A, power off any external signals connected to the SCB-68A before you power off your computer.

Using the SCB-68A in Direct Feedthrough Mode

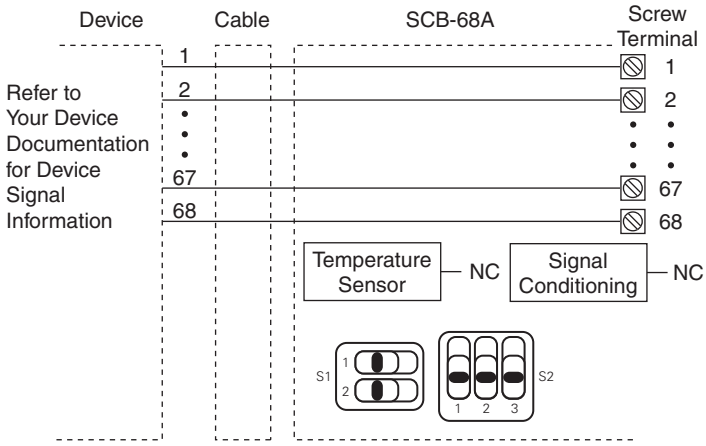
Devices without analog input functionality, as well as R Series, AO Series, and DIO/TIO Series devices, *must* use direct feedthrough mode. Move the switches to the direct feedthrough mode switch setting shown in Table 1-1.

Table 1-1. Direct Feedthrough Switch Setting

Switch Setting	Description
	**Direct feedthrough mode**—Move switches S1.1, S1.2, S2.1, S2.2, and S2.3 to the positions shown at left. In this mode: • All 68 signals from the device connect directly to screw terminals. Refer to Figure 1-3 for a detailed diagram.

[1] MAX 5.3 or later. You can select SCB-68 as your accessory in earlier versions of MAX.

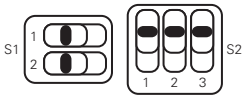
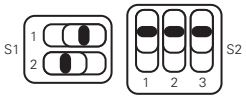
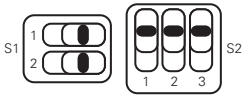
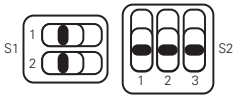
Figure 1-3. Direct Feedthrough Mode Switch Setting



Using the SCB-68A with MIO DAQ Devices

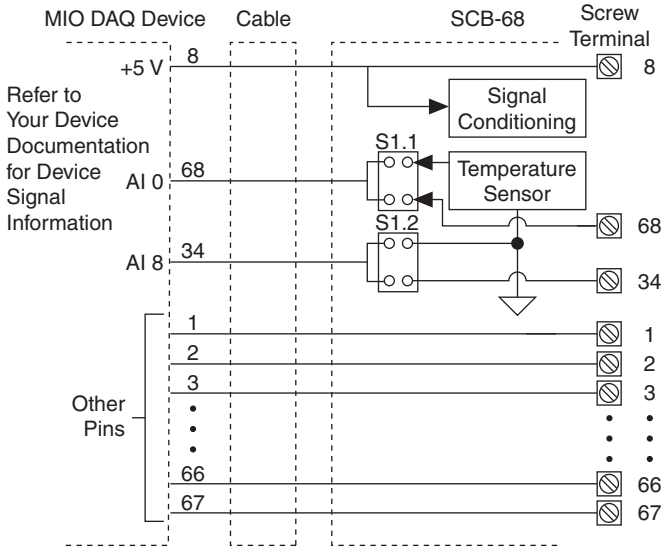
You can take measurements with the SCB-68A and multifunction I/O (MIO) DAQ devices, such as E/M/S/X Series devices, in a number of ways. The SCB-68A has a temperature sensor for cold-junction compensation (CJC) to accommodate thermocouples; switches S1.1 and S1.2 configure the temperature sensor for different analog input settings. Switches S2.1, S2.2, and S2.3 provide power to the signal conditioning area of the accessory. Table 1-2 shows the different switch settings for MIO DAQ devices.

Table 1-2. MIO DAQ Device Switch Settings

Switch Setting	Description
	**MIO with disabled temperature sensor mode (default configuration)***—Move switches S1.1, S1.2, S2.1, S2.2, and S2.3 to the positions shown at left. In this mode: • The temperature sensor is not used. • AI 0 and AI 8 are available on screw terminals. • +5 V power provided to signal conditioning area of the accessory. Refer to Figure 1-4 for a detailed diagram.
	**MIO with single-ended temperature sensor mode***,†—Move switches S1.1, S1.2, S2.1, S2.2, and S2.3 to the positions shown at left. In this mode: • The temperature sensor can be read using AI 0 in referenced single-ended (RSE) mode. • AI 8 is available on a screw terminal. • +5 V power provided to signal conditioning area of the accessory. Refer to Figure 1-4 for a detailed diagram.
	**MIO with differential temperature sensor mode***—Move switches S1.1, S1.2, S2.1, S2.2, and S2.3 to the positions shown at left. In this mode: • The temperature sensor can be read using AI 0 and AI 8 in differential mode. • +5 V power provided to signal conditioning area of the accessory. Refer to Figure 1-4 for a detailed diagram.
	**Direct feedthrough mode**—Move switches S1.1, S1.2, S2.1, S2.2, and S2.3 to the positions shown at left. In this mode: • All 68 signals from the device connect directly to screw terminals. Refer to Figure 1-3 for a detailed diagram.

* Not available on Connector 1 of NI 6225/6255 devices.
† Not available on S Series and Simultaneous MIO X Series devices.

Figure 1-4. MIO DAQ Device Modes Switch Settings



For detailed information about connections from floating or ground-referenced signal sources to analog inputs, refer to the *Connecting Analog Input Signals* section of Chapter 2, *Analog Input and Temperature Sensor Measurements*.

Mounting the SCB-68A

You can use the SCB-68A on a desktop, or mount it to a panel or a standard DIN rail.

Panel Mounting

Three keyholes are located on the back of the SCB-68A for mounting it to a panel or wall. To mount the SCB-68A to a board or panel, complete the following steps.

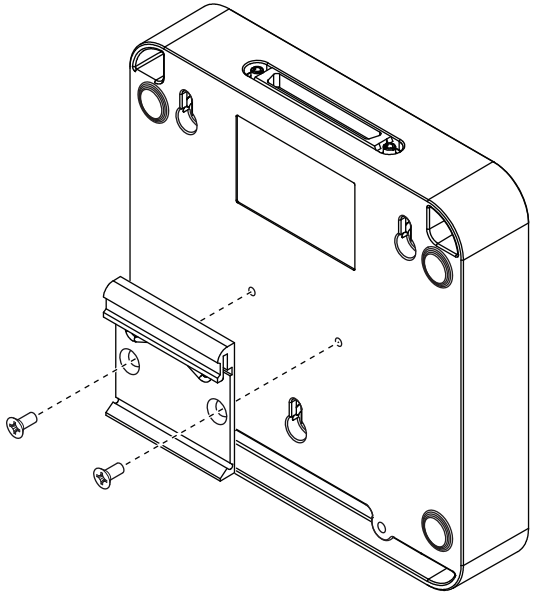
1. Download and print the panel mounting template PDF attached in the KnowledgeBase document, *SCB-68A Panel Mounting Template*. Go to `ni.com/info` and enter the Info Code `scb68amounting` to locate the KnowledgeBase.
2. Using the template, mark the three points on the panel. Verify that the narrow ends of the panel mounting screw keyholes are pointing up.
3. Screw #6-32 panhead machine screws or M3 panhead machine screws into the points marked on the panel, leaving room to easily remove the device from the panel. Installed screw height for both screw types (from the wall to the top of the screw) is 5 mm (0.2 in.).

DIN Rail Mounting

The NI 9913 DIN rail mounting kit (part number 781740-01) contains one clip for mounting the SCB-68A on a standard 35 mm DIN rail. Fasten the DIN rail clip to the accessory using two FLH #6-32 × 5/16” screws (included in the kit) with a #2 Phillips screwdriver, as shown in Figure 1-5.

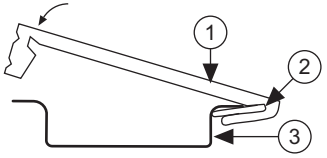
Note The threaded holes on the SCB-68A for DIN rail mounting should not be used more than five times. Unscrewing and reinstalling the DIN rail clip will produce a compromised connection between the DIN rail clip and accessory.

Figure 1-5. SCB-68A DIN Rail Clip Installation



Clip the chassis onto the DIN rail with the larger lip of the DIN rail clip positioned up, as shown in Figure 1-6.

Figure 1-6. DIN Rail Clip Parts Locator Diagram



1	DIN Rail Clip	2	DIN Rail Spring	3	DIN Rail

Securing the Cover on the SCB-68A

In most cases, attaching the cover with the integrated magnets is sufficient. To permanently secure the cover to the SCB-68A base, you will need two M3 × 6 (4-40 × 5/16) thread-forming Phillips panhead screws, such as Taptite® Trilobular® screws. You can purchase Taptite screws from many vendors. Complete the following steps.

1. Using a 3.5 mm (9/64 in.) diameter drill bit, drill two holes through the silkscreened crosshairs on the label side of the cover. When drilling, place the cover on a flat surface, such as a drill press, and drill slowly to minimize burrs.
2. Replace the cover on the base, lining up the drill holes with the holes in the enclosure.
3. Screw the M3 × 6 (4-40 × 5/16) screws in with a torque of 8–10 in. · lb.

Soldering and Desoldering Components on the SCB-68A

Some applications require you to make modifications to the SCB-68A, usually in the form of adding components to the printed circuit device.

Soldering Equipment

To solder components on the SCB-68A, you need the following:

☐ #1 and #2 Phillips screwdrivers

☐ 0.125 in. flathead screwdriver

☐ Soldering iron and solder

☐ Long nose pliers

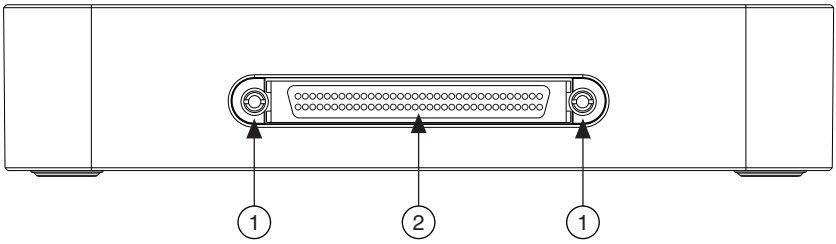
☐ Components specific to your application

Removing the SCB-68A Board from the Base

Complete the following steps to remove the SCB-68A from the base.

1. Disconnect the 68-pin cable from the SCB-68A, if connected, and remove the top cover.
2. Loosen the strain-relief screws, shown in Figure 1-1, with a #2 Phillips screwdriver.
3. Remove any signal wires from screw terminals with a flathead screwdriver.
4. Remove the printed circuit board mount screws and chassis ground lug, shown in Figure 1-2, with a #1 Phillips screwdriver.
5. Remove the 68-pin connector screws, shown in Figure 1-7, with a flathead screwdriver.

Figure 1-7. SCB-68A Back View



1	68-Pin Connector Screws	2	68-Pin I/O Connector

6. Tilt the PCB up and pull it out of the enclosure base.

Note The threaded holes on the SCB-68A for the printed circuit board mounting should not be used more than five times. Unscrewing and reinstalling the PCB will produce a compromised connection.

Soldering and Desoldering Guidelines

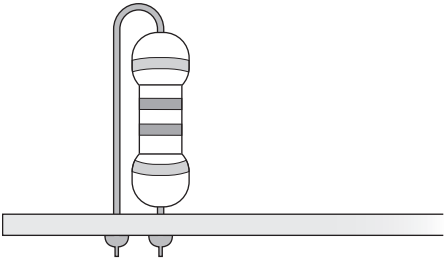
As you solder and desolder components on the SCB-68A, refer to Figure 1-2.

The SCB-68A ships with surface mount 0 Ω resistors in the F and G positions. You *must* remove the resistors to use the positions. Use a low-wattage soldering iron (20 to 30 W) when soldering to the SCB-68A.

To desolder on the SCB-68A, hot tweezer, low wattage tools work best. Be careful to avoid damaging the component pads when desoldering. Use only rosin-core electronic-grade solder because acid-core solder damages the printed-circuit device and components.

The pads on the SCB-68A require that you solder components on in a vertical fashion, as shown in Figure 1-8.

Figure 1-8. Recommended Resistor Installation



Related Documentation

For more information about using the SCB-68A with your DAQ device, refer to the following resources:

- Documentation for your DAQ device at ni.com/manuals
- *Measurement & Automation Explorer Help*
- *NI-DAQmx Help*
- NI KnowledgeBase at ni.com/kb
- NI Developer Zone at ni.com/zone

2

Analog Input and Temperature Sensor Measurements

This chapter covers many topics associated with taking analog input measurements, including information about the temperature sensor and thermocouple measurements. This chapter also describes how to condition signals by adding components to the open component locations of the SCB-68A for lowpass and highpass filtering, current input measurement, and attenuating voltage applications, as well as installing bias resistors.

Caution Add components at your own risk. NI is *not* liable for any damage resulting from improperly added components.

In addition to the applications described in this chapter, you can build many other types of signal conditioning using the component pads and the general-purpose breadboard area of the SCB-68A. Refer to the *Soldering and Desoldering Components on the SCB-68A* section of Chapter 1, *Getting Started with the SCB-68A*, for more information about adding components and for soldering and desoldering instructions.

After building one of the applications described in this chapter or your custom circuitry, refer to the *Setting up the SCB-68A* section of Chapter 1, *Getting Started with the SCB-68A*, for instructions about how to configure the SCB-68A in Measurement & Automation Explorer (MAX). You can create virtual channels in MAX to create a custom scale or map your voltage ranges to the type of transducer that you use.

Analog Input Circuitry and Channel Pad Configuration

When you use the SCB-68A with a 68-pin or 100-pin MIO DAQ device, you can use the component pads on the SCB-68A to condition 16 AI channels. Figure 2-1 shows the analog input and CJC circuitry on the SCB-68A.

Figure 2-1. Analog Input and Cold-Junction Compensation Circuitry

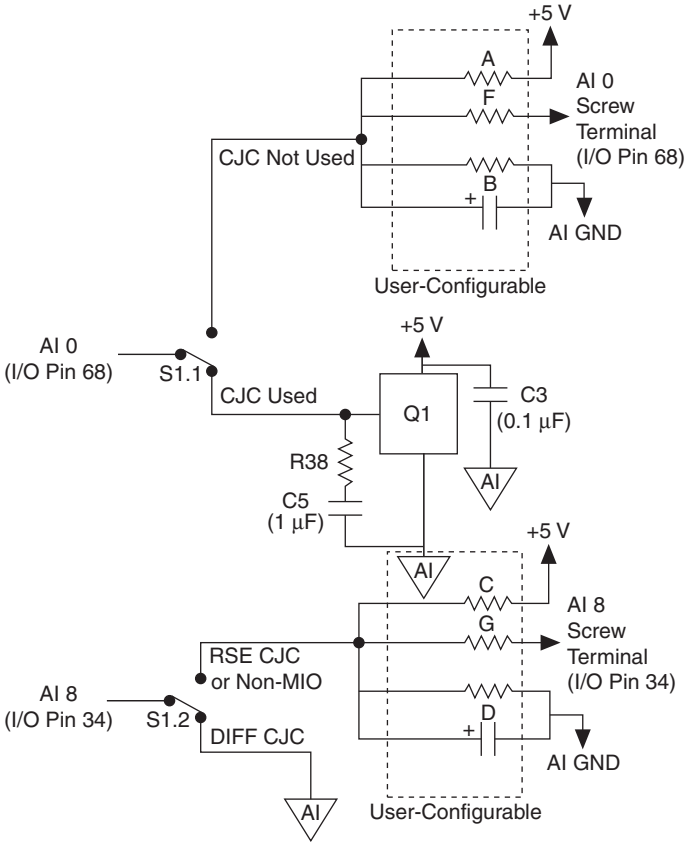
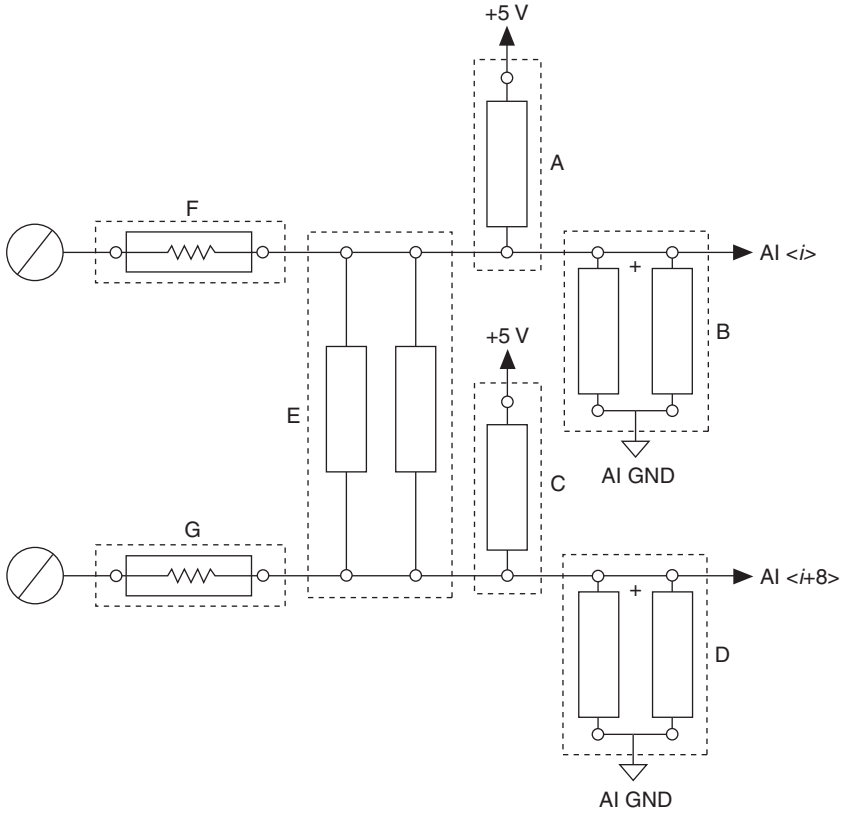


Figure 2-2 illustrates the basic AI channel configuration. You can use AI <*i*> and AI <*i*+8> as either a differential channel pair or as two single-ended channels.

Figure 2-2. Analog Input Channel Circuitry for AI <i> and AI <i+8>



To use the SCB-68A with ground-referenced single-ended inputs, do *not* use the open positions that connect the input to AI GND, positions B and D, for grounded sources as shown in Figure 2-3. Build any signal conditioning circuitry requiring a ground reference in the custom breadboard area using AI SENSE as the ground reference instead of building the circuitry in the open component positions.

Figure 2-3. Analog Input Channel Pad Configuration for AI <i> and AI <i+8>

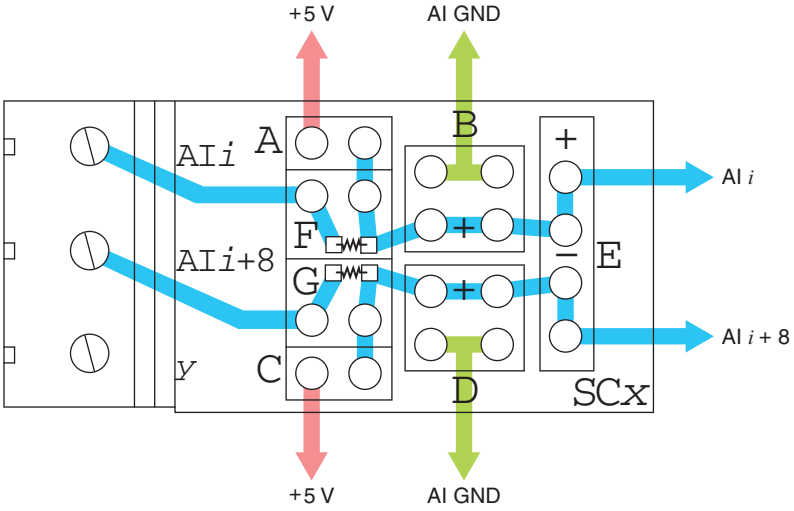


Table 2-1 correlates the component labels of the SCB-68A to component locations A through G for analog input signals.

Table 2-1. Analog Input Channels Component Locations

Channel		Positions A, B*, C, D*, E*, F†, and G†
Single-Ended	**Differential**	
AI 0, AI 8	AI 0+/–	SC0
AI 1, AI 9	AI 1+/–	SC1
AI 2, AI 10	AI 2+/–	SC2
AI 3, AI 11	AI 3+/–	SC3
AI 4, AI 12	AI 4+/–	SC4
AI 5, AI 13	AI 5+/–	SC5
AI 6, AI 14	AI 6+/–	SC6
AI 7, AI 15	AI 7+/–	SC7

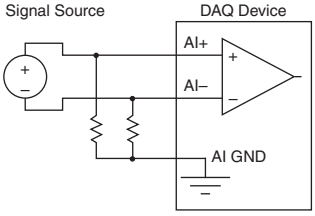
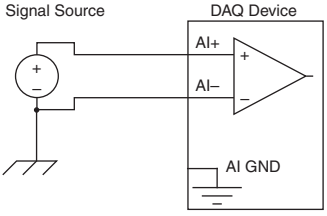
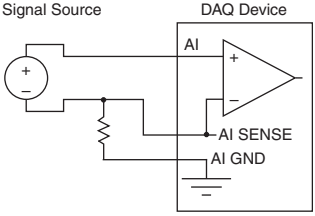
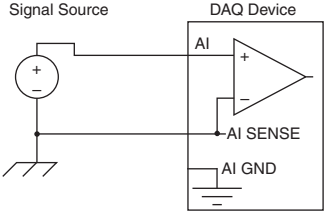
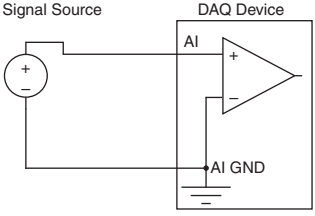
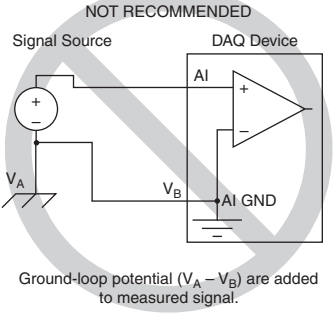
* B, D, and E positions contain through hole pads that can be used for two components to be connected in parallel.

† F and G positions contain a surface mount 0 Ω resistor; you *must* remove the resistor to use the position. If you remove your custom components from the F or G position, you *must* reinstall a 0 Ω resistor.

Connecting Analog Input Signals

Table 2-2 summarizes the recommended input configuration for both types of signal sources.

Table 2-2. Analog Input Configuration

AI Ground-Reference Setting*	Floating Signal Sources (Not Connected to Building Ground) Examples: • Ungrounded thermocouples • Signal conditioning with isolated outputs • Battery devices	Ground-Referenced Signal Sources* Example: • Plug-in instruments with non-isolated outputs
Differential (DIFF)		
Non-Referenced Single-Ended (NRSE)		
Referenced Single-Ended (RSE)		

* Refer to the documentation for your DAQ device for descriptions of the RSE, NRSE, and DIFF modes, analog input signal sources, and software considerations.

Floating Signal Sources

A floating signal source is not connected to the building ground system, but has an isolated ground-reference point. Some examples of floating signal sources are outputs of transformers, thermocouples, battery-powered devices, optical isolators, and isolation amplifiers. An instrument or device that has an isolated output is a floating signal source.

When to Use Differential Connections with Floating Signal Sources

Use differential input connections for any channel that meets any of the following conditions:

- The input signal is low-level (less than 1 V).
- The leads connecting the signal to the device are greater than 3 m (10 ft).
- The input signal requires a separate ground-reference point or return signal.
- The signal leads travel through noisy environments.
- Two analog input channels, AI+ and AI–, are available for the signal.

Differential signal connections reduce noise pickup and increase common-mode noise rejection. Differential signal connections also allow input signals to float within the common-mode limits of the NI-PGIA.

Refer to the *Using Differential Connections for Floating Signal Sources* section for more information about differential connections.

When to Use Non-Referenced Single-Ended (NRSE) Connections with Floating Signal Sources

Only use NRSE input connections if the input signal meets the following conditions:

- The input signal is high-level (greater than 1 V).
- The leads connecting the signal to the device are less than 3 m (10 ft).

Differential input connections are recommended for greater signal integrity for any input signal that does not meet the preceding conditions.

In the single-ended modes, more electrostatic and magnetic noise couples into the signal connections than in differential configurations. The coupling is the result of differences in the signal path. Magnetic coupling is proportional to the area between the two signal conductors. Electrical coupling is a function of how much the electric field differs between the two conductors.

With this type of connection, the NI-PGIA rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the device ground.

Refer to the documentation for your DAQ device for more information about NRSE connections.

When to Use Referenced Single-Ended (RSE) Connections with Floating Signal Sources

Only use RSE input connections if the input signal meets the following conditions:

- The input signal can share a common reference point, AI GND, with other signals that use RSE.
- The input signal is high-level (greater than 1 V).
- The leads connecting the signal to the device are less than 3 m (10 ft).

Differential input connections are recommended for greater signal integrity for any input signal that does not meet the preceding conditions.

In the single-ended modes, more electrostatic and magnetic noise couples into the signal connections than in differential configurations. The coupling is the result of differences in the signal path. Magnetic coupling is proportional to the area between the two signal conductors. Electrical coupling is a function of how much the electric field differs between the two conductors.

With this type of connection, the NI-PGIA rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the device ground.

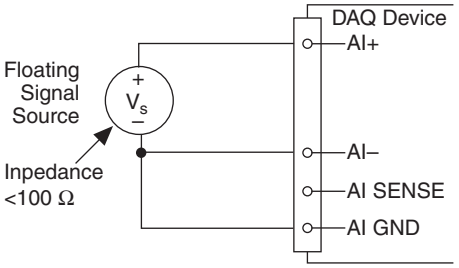
Refer to the documentation for your DAQ device for more information about RSE connections.

Using Differential Connections for Floating Signal Sources

It is important to connect the negative lead of a floating source to AI GND (either directly or through a bias resistor). Otherwise, the source can float out of the maximum working voltage range of the NI-PGIA and the DAQ device returns erroneous data.

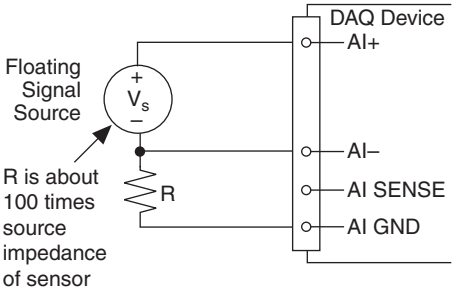
The easiest way to reference the source to AI GND is to connect the positive side of the signal to AI+ and connect the negative side of the signal to AI GND as well as to AI– without using resistors. This connection works well for DC-coupled sources with low source impedance (<100 Ω).

Figure 2-4. Differential Connections for Floating Signal Sources without Bias Resistors



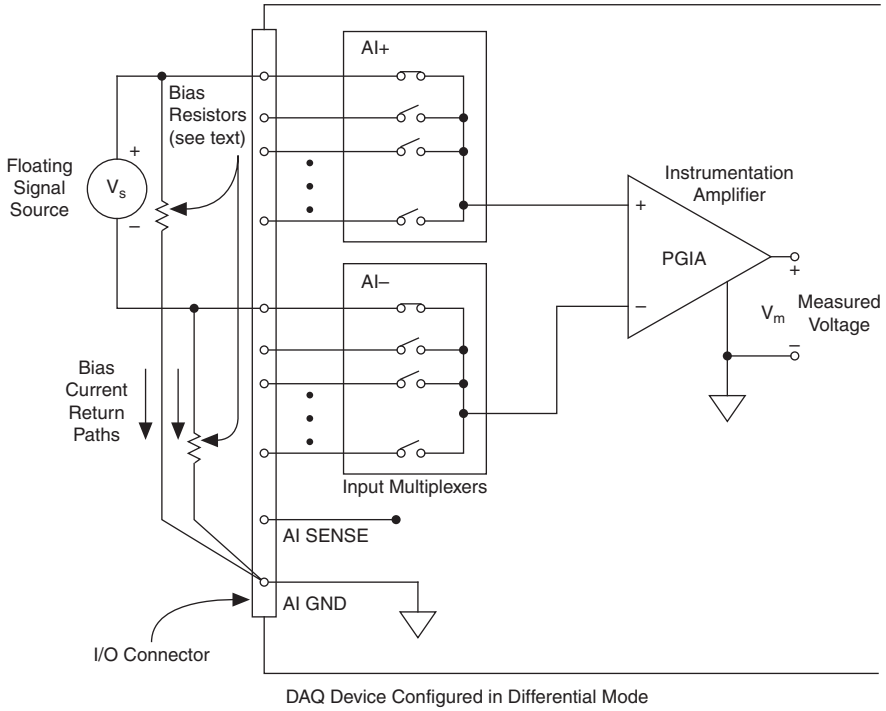
However, for larger source impedances, this connection leaves the differential signal path significantly off balance. Noise that couples electrostatically onto the positive line does not couple onto the negative line because it is connected to ground. This noise appears as a differential mode signal instead of a common-mode signal, and thus appears in your data. In this case, instead of directly connecting the negative line to AI GND, connect the negative line to AI GND through a resistor that is about 100 times the equivalent source impedance. The resistor puts the signal path nearly in balance, so that about the same amount of noise couples onto both connections, yielding better rejection of electrostatically coupled noise. This configuration does not load down the source (other than the very high input impedance of the NI-PGIA).

Figure 2-5. Differential Connections for Floating Signal Sources with Single Bias Resistor



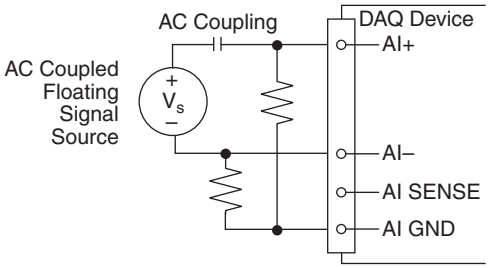
You can fully balance the signal path by connecting another resistor of the same value between the positive input and AI GND, as shown in Figure 2-6. This fully balanced configuration offers slightly better noise rejection, but has the disadvantage of loading the source down with the series combination (sum) of the two resistors. If, for example, the source impedance is 2 kΩ and each of the two resistors is 100 kΩ, the resistors load down the source with 200 kΩ and produce a –1% gain error.

Figure 2-6. Floating Signal Source Differential Connections with Balanced Bias Resistors



Both inputs of the NI-PGIA require a DC path to ground in order for the NI-PGIA to work. If the source is AC coupled (capacitively coupled), the NI-PGIA needs a resistor between the positive input and AI GND. If the source has low-impedance, choose a resistor that is large enough not to significantly load the source, but small enough not to produce significant input offset voltage as a result of input bias current (typically 100 kΩ to 1 MΩ). In this case, connect the negative input directly to AI GND. If the source has high output impedance, balance the signal path as previously described using the same value resistor on both the positive and negative inputs; be aware that there is some gain error from loading down the source, as shown in Figure 2-7.

Figure 2-7. AC-Coupled Floating Source Differential Connections with Balanced Bias Resistors



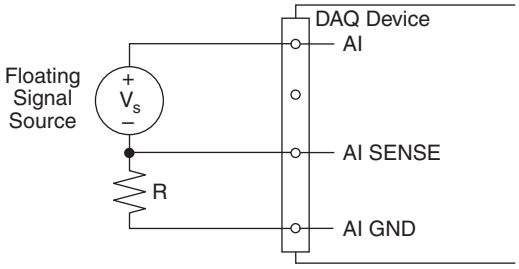
Refer to the *Installing Bias Resistors* section for information about installing bias resistors on the SCB-68A.

Using Non-Referenced Single-Ended (NRSE) Connections for Floating Signal Sources

It is important to connect the negative lead of a floating signals source to AI GND (either directly or through a resistor). Otherwise the source may float out of the valid input range of the NI-PGIA and the DAQ device returns erroneous data.

Figure 2-8 shows a floating source connected to the DAQ device in NRSE mode.

Figure 2-8. NRSE Connections for Floating Signal Sources



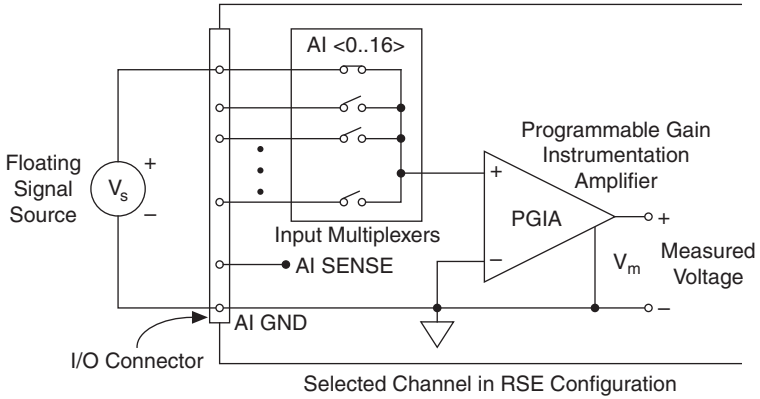
All of the bias resistor configurations discussed in the *Using Differential Connections for Floating Signal Sources* section apply to the NRSE bias resistors as well. Replace AI– with AI SENSE in Figures 2-4, 2-5, 2-6, and 2-7 for configurations with zero to two bias resistors. The noise rejection of NRSE mode is better than RSE mode because the AI SENSE connection is made remotely near the source. However, the noise rejection of NRSE mode is worse than DIFF mode because the AI SENSE connection is shared with all channels rather than being cabled in a twisted pair with the AI+ signal.

Using the DAQ Assistant, you can configure the channels for RSE or NRSE input modes.

Using Referenced Single-Ended (RSE) Connections for Floating Signal Sources

Figure 2-9 shows how to connect a floating signal source to the DAQ device configured for RSE mode.

Figure 2-9. RSE Connections for Floating Signal Sources



Using the DAQ Assistant, you can configure the channels for RSE or NRSE input modes.

Ground-Referenced Signal Sources

A ground-referenced signal source is a signal source connected to the building system ground. It is already connected to a common ground point with respect to the device, assuming that the computer is plugged into the same power system as the source. Non-isolated outputs of instruments and devices that plug into the building power system fall into this category.

The difference in ground potential between two instruments connected to the same building power system is typically between 1 and 100 mV, but the difference can be much higher if power distribution circuits are improperly connected. If a grounded signal source is incorrectly measured, this difference can appear as measurement error. Follow the connection instructions for grounded signal sources to eliminate this ground potential difference from the measured signal.

When to Use Differential Connections with Ground-Referenced Signal Sources

Use DIFF input connections for any channel that meets any of the following conditions:

- The input signal is low level (less than 1 V).
- The leads connecting the signal to the device are greater than 3 m (10 ft).
- The input signal requires a separate ground-reference point or return signal.
- The signal leads travel through noisy environments.
- Two analog input channels, AI+ and AI–, are available.

DIFF signal connections reduce noise pickup and increase common-mode noise rejection. DIFF signal connections also allow input signals to float within the common-mode limits of the NI-PGIA.

Refer to the *Using Differential Connections for Ground-Referenced Signal Sources* section for more information about differential connections.

When to Use Non-Referenced Single-Ended (NRSE) Connections with Ground-Referenced Signal Sources

Only use NRSE connections if the input signal meets the following conditions:

- The input signal is high-level (greater than 1 V).
- The leads connecting the signal to the device are less than 3 m (10 ft).
- The input signal can share a common reference point with other signals.

DIFF input connections are recommended for greater signal integrity for any input signal that does not meet the preceding conditions.

In the single-ended modes, more electrostatic and magnetic noise couples into the signal connections than in DIFF configurations. The coupling is the result of differences in the signal path. Magnetic coupling is proportional to the area between the two signal conductors. Electrical coupling is a function of how much the electric field differs between the two conductors.

With this type of connection, the NI-PGIA rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the device ground.

Refer to the *Using Non-Referenced Single-Ended (NRSE) Connections for Ground-Referenced Signal Sources* section for more information about NRSE connections.

When to Use Referenced Single-Ended (RSE) Connections with Ground-Referenced Signal Sources

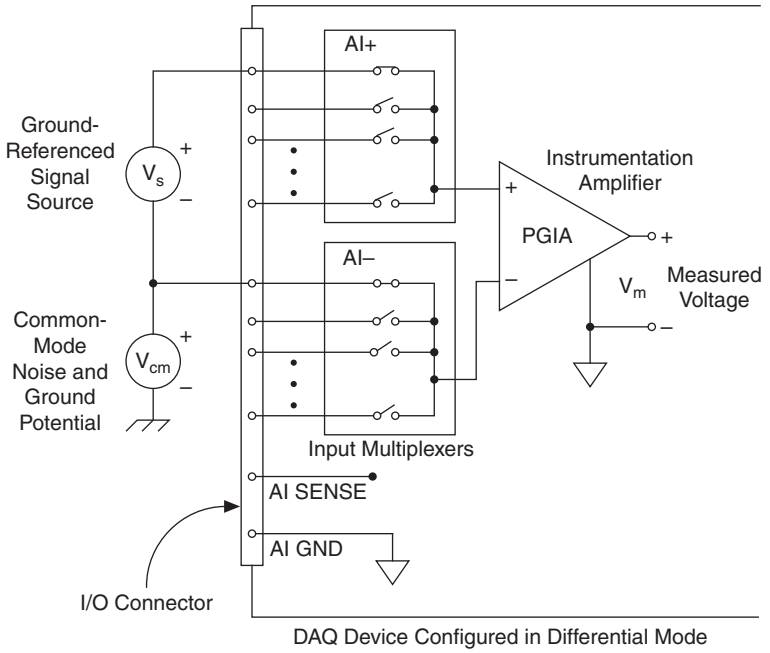
Do *not* use RSE connections with ground-referenced signal sources. Use NRSE or DIFF connections instead.

As shown in the bottom-rightmost cell of Table 2-2, there can be a potential difference between AI GND and the ground of the sensor. In RSE mode, this ground loop causes measurement errors.

Using Differential Connections for Ground-Referenced Signal Sources

Figure 2-10 shows how to connect a ground-referenced signal source to the DAQ device configured in differential mode.

Figure 2-10. Differential Connections for Ground-Referenced Signal Sources



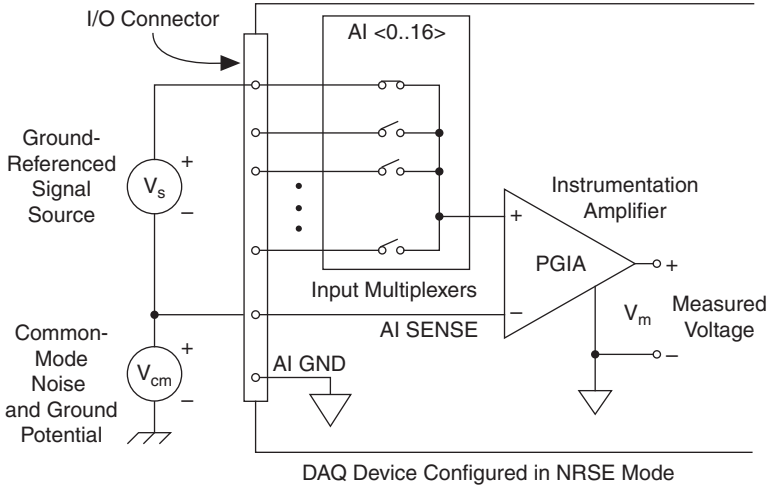
With this type of connection, the NI-PGIA rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the device ground, shown as V_{cm} in the figure.

AI+ and AI– must both remain within ±11 V of AI GND.

Using Non-Referenced Single-Ended (NRSE) Connections for Ground-Referenced Signal Sources

Figure 2-11 shows how to connect ground-reference signal sources in NRSE mode.

Figure 2-11. Single-Ended Connections for Ground-Referenced Signal Sources (NRSE Configuration)



AI <0..*x*> and AI SENSE must both remain within ±11 V of AI GND.

To measure a single-ended, ground-referenced signal source, you must use the NRSE ground-reference setting. Connect the signal to one of AI <0..*x*> and connect the signal local ground reference to AI SENSE. AI SENSE is internally connected to the negative input of the NI-PGIA. Therefore, the ground point of the signal connects to the negative input of the NI-PGIA.

Any potential difference between the device ground and the signal ground appears as a common-mode signal at both the positive and negative inputs of the NI-PGIA, and this difference is rejected by the amplifier. If the input circuitry of a device were referenced to ground, as it is in the RSE ground-reference setting, this difference in ground potentials would appear as an error in the measured voltage.

You can configure the channels for RSE or NRSE input modes using DAQ Assistant.

Using the Temperature Sensor

To accommodate thermocouples with DAQ devices, the SCB-68A has a temperature sensor for cold-junction compensation (CJC), shown in Figure 1-2, *SCB-68A Printed Circuit Board Diagram*. To power the temperature sensor, set the switches for single-ended or differential mode as described in the *Using the SCB-68A with MIO DAQ Devices* section of Chapter 1, *Getting Started with the SCB-68A*. This configuration also powers the signal conditioning area and circuitry. Refer to Figure 2-1 for a diagram of the CJC circuitry on the SCB-68A.

Taking Thermocouple Measurements

You can measure thermocouples in differential or single-ended configuration:

- Differential configuration has better noise immunity. Use bias resistors when the DAQ device is in differential input mode, as described in the *Installing Bias Resistors* section.
- Single-ended configuration has twice as many inputs. For single-ended configuration, set your DAQ device for referenced single-ended (RSE) input mode.

The maximum voltage level thermocouples generate is typically only a few millivolts. You should use a DAQ device with high gain for best resolution. For more information about thermocouple measurements, refer to the NI Developer Zone tutorial, *Taking Thermocouple Temperature Measurements*. To access this document, go to `ni.com/info` and enter the Info Code `rdtttm`.

The DAQ device must have a ground reference because thermocouples are floating signal sources. For more information about floating signal sources, refer to the *Connecting Analog Input Signals* section. For more information about field wiring, refer to the NI Developer Zone document, *Field Wiring and Noise Considerations for Analog Signals*. To access this document, go to `ni.com/info` and enter the Info Code `rdfwn3`.

CJC with the SCB-68A is accurate only if the temperature sensor reading is close to the actual temperature of the screw terminals. Therefore, when reading thermocouples, keep the SCB-68A away from drafts or other temperature gradients, such as those caused by heaters, radiators, fans, and warm equipment.

Temperature Sensor Output and Accuracy

The SCB-68A temperature sensor outputs 10 mV/°C and has an accuracy of ±1 °C.

You also can determine the temperature using the following formulas:

$$T_C = 100 \times V_t$$

$$T_K = T_C + 273.15$$

$$T_F = \left[\frac{9}{5} \times T_C\right] + 32$$

where V_t is the temperature sensor output voltage;

and T_C, T_K, and T_F are the temperature readings in degrees Celsius, Kelvin, and Fahrenheit, respectively.

Thermocouple Sources of Error

When taking thermocouple measurements with the SCB-68A, the possible sources of error are as follows:

- **Compensation error**—Can arise from two sources—inaccuracy of the temperature sensor and temperature differences between the temperature sensor and the screw terminals. The temperature sensor on the SCB-68A is specified to be accurate to ±1 °C. You can minimize temperature differences between the temperature sensor and the screw terminals by keeping the SCB-68A away from drafts, heaters, and warm equipment.
- **Linearization error**—A consequence of the polynomials being approximations of the true thermocouple output. The linearization error depends upon the degree of polynomial used.
- **Measurement error**—The result of inaccuracies in the DAQ device. These inaccuracies include gain, offset, and noise. Accuracy can be calculated from the DAQ device specifications. For best results, you must use a well-calibrated DAQ device. NI recommends that you run self-calibration on your DAQ device frequently to reduce error.
- **Thermocouple wire error**—The result of inconsistencies in the thermocouple manufacturing process. These inconsistencies, or nonhomogeneities, are the result of defects or impurities in the thermocouple wire. The errors vary depending on the thermocouple type and the gauge of wire used, but an error of ±2 °C is typical. For more information about thermocouple wire errors and more specific data, consult the thermocouple manufacturer.
- **Noise error**—Error due to inherent system noise. Use the average of a large number of samples to obtain the most accurate reading. Noisy environments require averaging more samples for greater accuracy.

$$\frac{white\ noise}{\sqrt{number\ of\ samples}} = resulting\ noise$$

For best results, use the average of at least 100 readings to reduce the effects of noise; typical absolute accuracies should then be about ±2 °C.

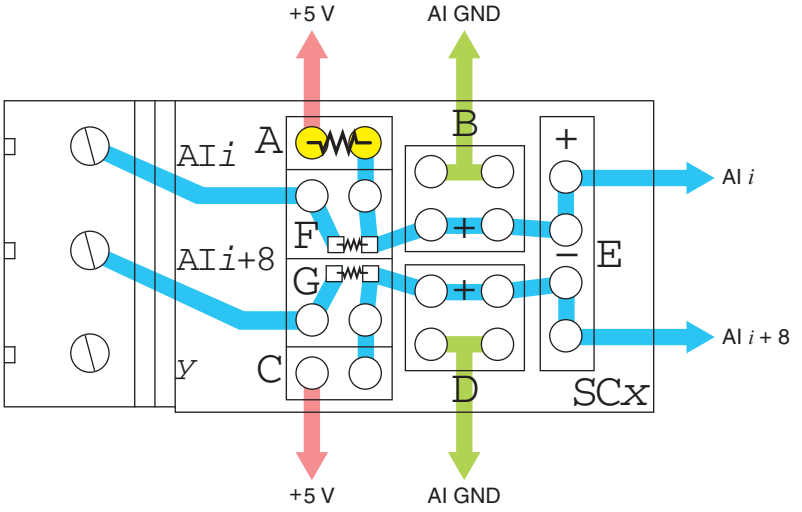
Open Thermocouple Detection

You can build open thermocouple detection circuitry by connecting a high-value resistor between the positive input and +5 V. A resistor of a few MΩ or more is sufficient, but a high-value resistor allows you to detect an open or defective thermocouple.

Note Refer to the *Soldering and Desoldering Components on the SCB-68A* section of Chapter 1, *Getting Started with the SCB-68A*, for more information about adding components and for soldering and desoldering instructions.

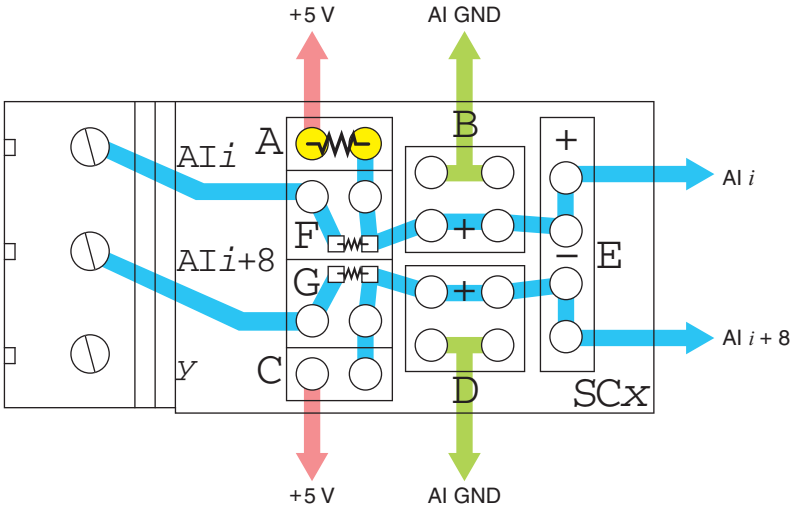
- **Differential analog input open thermocouple detection**—Use position A to connect a high-value resistor between the positive input and +5 V. Leave the 0 Ω resistors at positions F and G in place for each channel used. Refer to Table 2-1 for component positions for all analog input channels.

Figure 2-12. Differential Analog Input Open Thermocouple Detection



- **Single-ended analog input open thermocouple detection**—Use position A for one channel and C for the next channel when you connect a high-value resistor between the positive input and +5 V. Leave the 0 Ω resistors at positions F and G in place for each channel used. Refer to Table 2-1 for component positions for all analog input channels.

Figure 2-13. Single-Ended Analog Input Open Thermocouple Detection on AI <i>



If the thermocouple opens, the voltage measured across the input terminals rises to +5 V, a value much larger than any legitimate thermocouple voltage. You can create a bias current return path by using a 100 kΩ resistor between the negative input and AI GND.

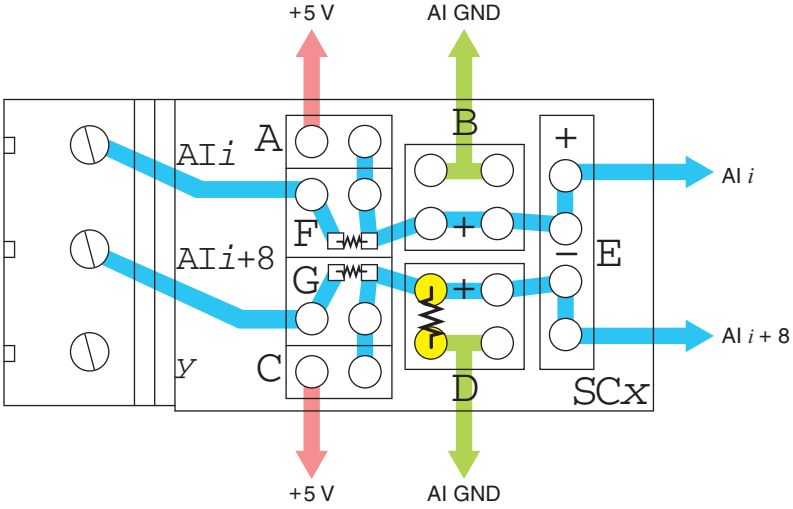
Thermocouple Input Filtering

To reduce noise, you can connect a simple one-pole RC lowpass filter to the analog inputs of the SCB-68A. Refer to the *One-Pole Lowpass RC Filter* section for more information.

Installing Bias Resistors

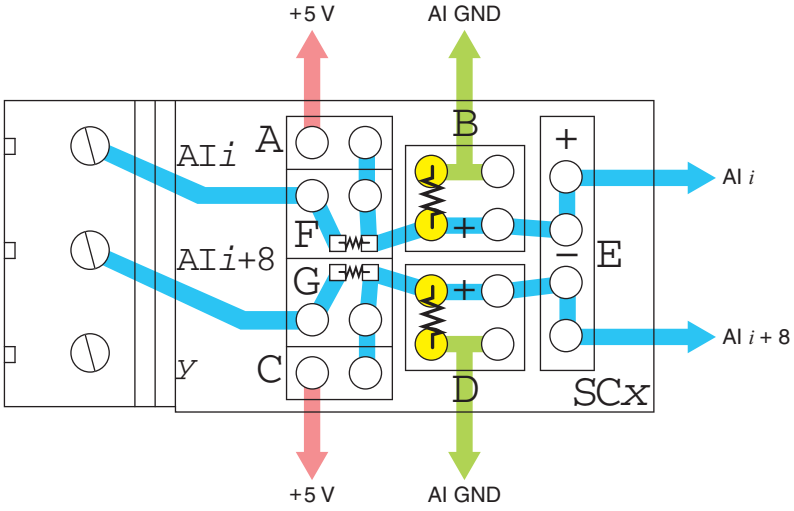
To install a single bias resistor on the negative line (AI–) of a differential pair, put the resistor in position D on the SCB-68A, as shown in Figure 2-14. Leave the 0 Ω resistors at positions F and G in place for each channel used.

Figure 2-14. AI Differential Configuration with Single Bias Resistor



To install balanced bias resistors, put resistors in positions B and D on the SCB-68A, as shown in Figure 2-15. Leave the 0 Ω resistors at positions F and G in place for each channel used.

Figure 2-15. AI Differential Configuration with Balanced Bias Resistors



Lowpass Filtering

Lowpass filters highly or completely attenuate signals with frequencies above the cut-off frequency, or high-frequency stopband signals. Lowpass filters do not attenuate signals with frequencies below the cut-off frequency, or low-frequency passband signals. Ideally, lowpass filters have a phase shift that is linear with respect to frequency. This linear phase shift delays signal components of all frequencies by a constant time, independent of frequency, thereby preserving the overall shape of the signal.

In practice, lowpass filters subject input signals to a mathematical transfer function that approximates the characteristics of an ideal filter. By analyzing the Bode Plot, or the plot that represents the transfer function, you can determine the filter characteristics.

Figures 2-16 and 2-17 show the Bode Plots for the ideal filter and the real filter, respectively, and indicate the attenuation of each transfer function.

Figure 2-16. Transfer Function Attenuation for an Ideal Filter

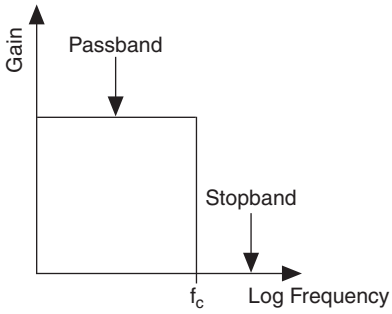
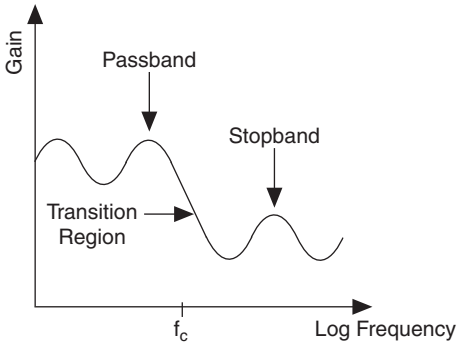


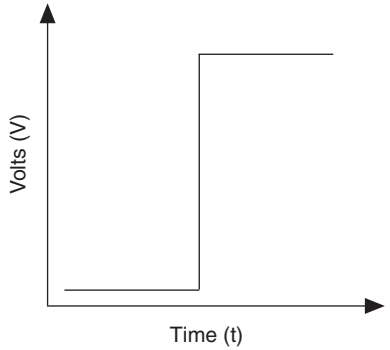
Figure 2-17. Transfer Function Attenuation for a Real Filter



The cut-off frequency, f_c, is defined as the frequency beyond which the gain drops 3 dB. Figure 2-16 shows how an ideal filter causes the gain to drop to zero for all frequencies greater than f_c. Thus, f_c does not pass through the filter to its output. Instead of having a gain of absolute zero for frequencies greater than f_c, the real filter has a transition region between the passband and the stopband, a ripple in the passband, and a stopband with a finite attenuation gain.

Real filters have some nonlinearity in their phase response, causing signals at higher frequencies to be delayed longer than signals at lower frequencies and resulting in an overall shape distortion of the signal. For example, when the square wave, shown in Figure 2-18, enters a filter, an ideal filter smooths the edges of the input, whereas a real filter causes some ringing in the signal as the higher frequency components of the signal are delayed.

Figure 2-18. Square Wave Input Signal



Figures 2-19 and 2-20 show the difference in response to a square wave between an ideal and a real filter, respectively.

Figure 2-19. Response of an Ideal Filter to a Square Wave Input Signal

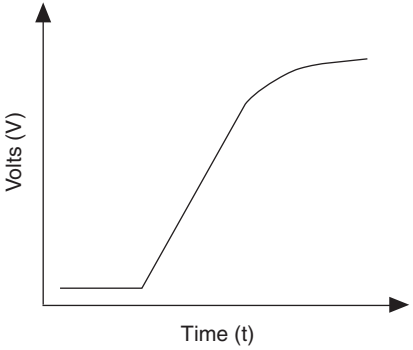
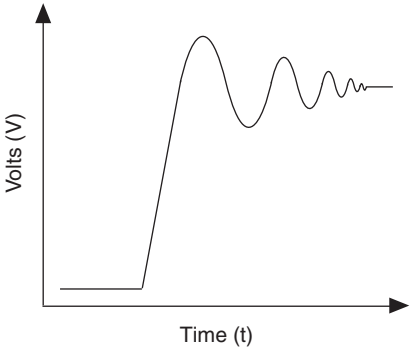


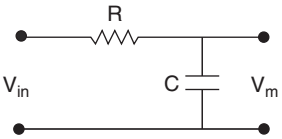
Figure 2-20. Response of a Real Filter to a Square Wave Input Signal



One-Pole Lowpass RC Filter

Figure 2-21 shows the transfer function of a simple series circuit consisting of a resistor (R) and capacitor (C) when the voltage across R is assumed to be the output voltage (V_m).

Figure 2-21. Simple RC Lowpass Filter



The transfer function is a mathematical representation of a one-pole lowpass filter, with a time constant of:

$$\frac{1}{2\pi RC}$$

Use Equation 2-1 to design a lowpass filter for a simple resistor and capacitor circuit, where the values of the resistor and capacitor alone determine f_c:

$$T(s) = \frac{G}{1 + (2\pi RC)s} \tag{2-1}$$

where G is the DC gain and s represents the frequency domain.

Selecting Components for Lowpass Filtering

To determine the value of the components in the circuit, fix R (10 kΩ is reasonable) and isolate C from Equation 2-1 as follows:

$$C = \frac{1}{2\pi R f_c} \tag{2-2}$$

The cut-off frequency in Equation 2-2 is f_c.

For best results, choose a resistor that has the following characteristics:

- Low wattage of approximately 0.125 W
- Precision of at least 5%
- Temperature stability
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

Choose a capacitor that has the following suggested characteristics:

- AXL or RDL package
- Tolerance of 20%
- Maximum voltage of at least 25 V

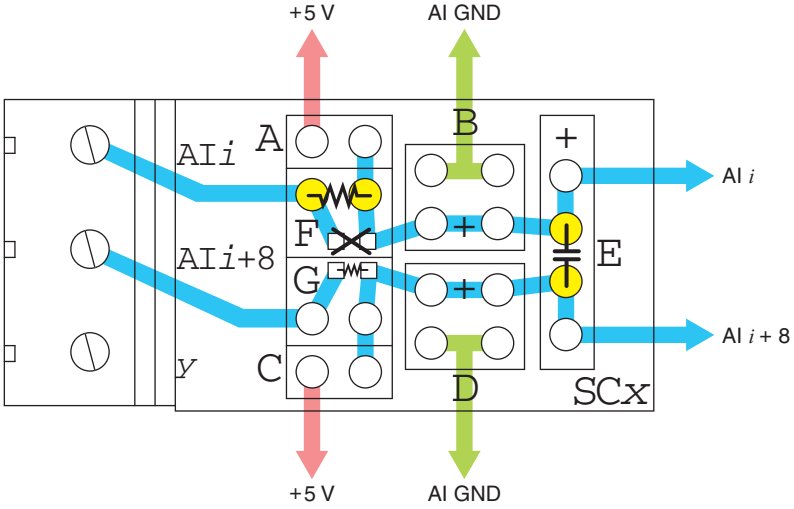
Adding Components for Lowpass Filters on Analog Input Signals

Using the circuit shown in Figure 2-21, you can use a two-component circuit to build a simple RC filter with analog input. You can build a lowpass filter for the following analog input modes:

- **Differential analog input lowpass filter**—To build a differential lowpass filter, refer to Figure 2-22. Add the resistor to position F and the capacitor to position E. Refer to Table 2-1 for component positions for all analog input channels.

  The SCB-68A ships with a surface mount 0 Ω resistor in the F position. You *must* remove the resistor to use the position.

Figure 2-22. SCB-68A Circuit Diagram for Differential Analog Input Lowpass Filter

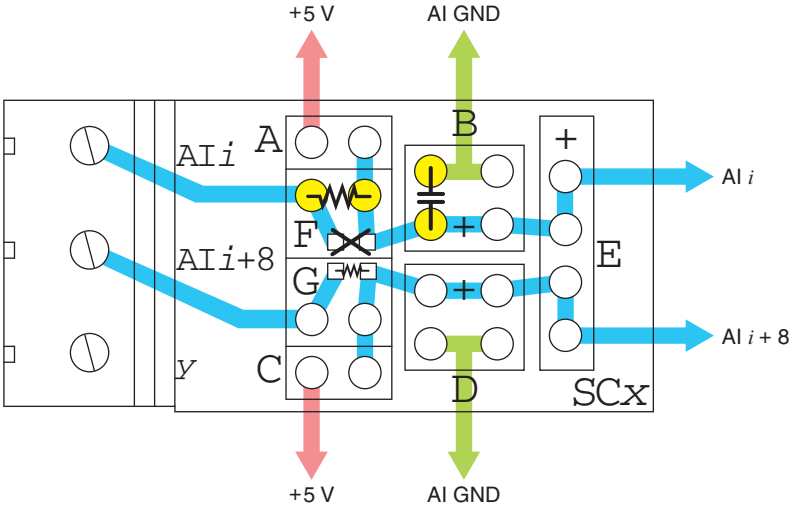


- **Single-ended analog input lowpass filter**—To build a single-ended lowpass filter, refer to Figure 2-23. Add the resistor to position F or G, depending on the AI channel you are using. Add the capacitor to position B or D, depending on the AI channel you are using. Refer to Table 2-1 for component positions for all analog input channels.

  The SCB-68A ships with a surface mount 0 Ω resistors in the F and G positions. You *must* remove the resistor to use the position.

Note Filtering increases the settling time of the instrumentation amplifier to the time constant of the filter used. Adding RC filters to scanning channels greatly reduces the practical scanning rate, since the instrumentation amplifier settling time can be increased to $10T$ or longer, where $T = (R)(C)$.

Figure 2-23. SCB-68A Circuit Diagram for Single-Ended Analog Input Lowpass Filter on AI <i>



Analog Input Lowpass Filtering Applications

The following applications benefit from lowpass filtering:

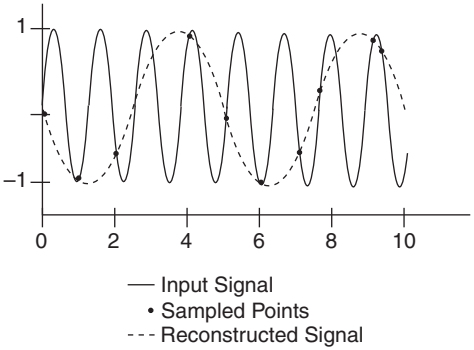
- **Noise filtering**—You can use a lowpass filter to highly attenuate the noise frequency on a measured signal. For example, power lines commonly add a noise frequency of 60 Hz. Adding a filter with f_c<60 Hz at the input of the measurement system causes the noise frequency to fall into the stopband.

  Referring to Equation 2-2, fix the resistor value at 10 kΩ to calculate the capacitor value and choose a commercial capacitor value that satisfies the following relationship:

$$C > \frac{1}{2\pi(10,000)(60)} \qquad (2\text{-}3)$$

- **Antialiasing filtering**—Aliasing causes high-frequency signal components to appear as a low-frequency signal, as Figure 2-24 shows.

Figure 2-24. Aliasing of a High-Frequency Signal



The solid line depicts a high-frequency signal being sampled at the indicated points. When these points are connected to reconstruct the waveform, as shown by the dotted line, the signal appears to have a lower frequency. Any signal with a frequency greater than one-half of its sample rate is aliased and incorrectly analyzed as having a frequency below one-half the sample rate. This limiting frequency of one-half the sample rate is called the Nyquist frequency.

To prevent aliasing, remove all signal components with frequencies greater than the Nyquist frequency from input signals before those signals are sampled. Once a data sample is aliased, it is impossible to accurately reconstruct the original signal.

To design a lowpass filter that attenuates signal components with a frequency higher than half of the Nyquist frequency, substitute the half Nyquist value for the f_c value in Equation 2-3.

Note (NI 6115/6120/6289 Devices Only) Some devices, such as the NI 6115/6120/6289, provide filters and may not need antialiasing filters implemented at the SCB-68A terminal block. Refer to your device documentation for more information.

Highpass Filtering

Highpass filters highly or completely attenuate signals with frequencies below the cut-off frequency, or low-frequency stopband signals. Highpass filters do not attenuate signals with frequencies above the cut-off frequency, or high-frequency passband signals.

The cut-off frequency, f_c, is defined as the frequency below which the gain drops 3 dB. Figure 2-25 shows how an ideal filter causes the gain to drop to zero for all frequencies less than f_c. Thus, f_c does not pass through the filter to its output.

In practice, highpass filters subject input signals to a mathematical transfer function that approximates the characteristics of an ideal filter. By analyzing the Bode Plot, or the plot that represents the transfer function, you can determine the filter characteristics.

Figures 2-25 and 2-26 show the Bode Plots for the ideal filter and the real filter, respectively, and indicate the attenuation of each transfer function.

Figure 2-25. Transfer Function Attenuation for an Ideal Filter

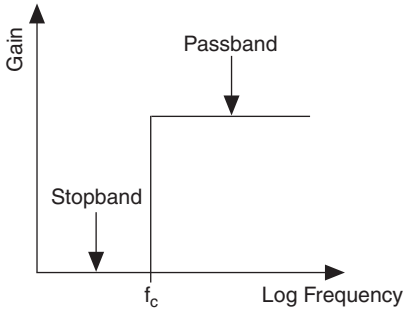
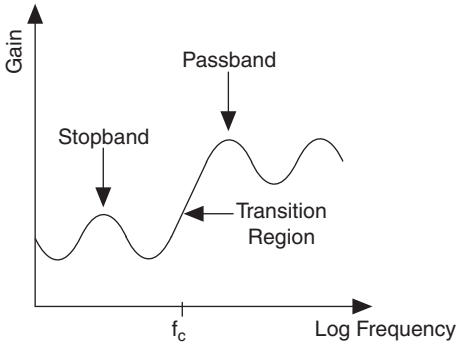


Figure 2-26. Transfer Function Attenuation for a Real Filter

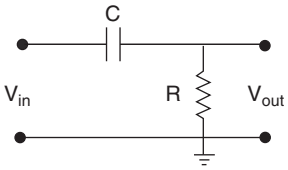


Instead of having a gain of absolute zero for frequencies less than f_c, the real filter has a transition region between the passband and the stopband, a ripple in the passband, and a stopband with a finite attenuation gain.

One-Pole Highpass RC Filter

Figure 2-27 shows the transfer function of a simple series circuit consisting of a resistor (R) and capacitor (C) when the voltage across R is assumed to be the output voltage (V_m).

Figure 2-27. Simple RC Highpass Circuit



The transfer function is a mathematical representation of a one-pole highpass filter, with a time constant of:

$$\frac{1}{2\pi RC}$$

Use Equation 2-4 to design a lowpass filter for a simple resistor and capacitor circuit, where the values of the resistor and capacitor alone determine f_c:

$$T(s) = \frac{G}{1 + (2\pi RC)s} \tag{2-4}$$

where G is the DC gain and s represents the frequency domain.

Selecting Components for Highpass Filtering

To determine the value of the components in the circuit, fix R (10 kΩ is reasonable) and isolate C from Equation 2-4 as follows:

$$C = \frac{1}{2\pi R f_c} \tag{2-5}$$

The cutoff frequency in Equation 2-5 is f_c.

For best results, choose a resistor that has the following characteristics:

- Low wattage of approximately 0.125 W
- Precision of at least 5%
- Temperature stability
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

Choose a capacitor that has the following suggested characteristics:

- AXL or RDL package
- Tolerance of 20%
- Maximum voltage of at least 25 V

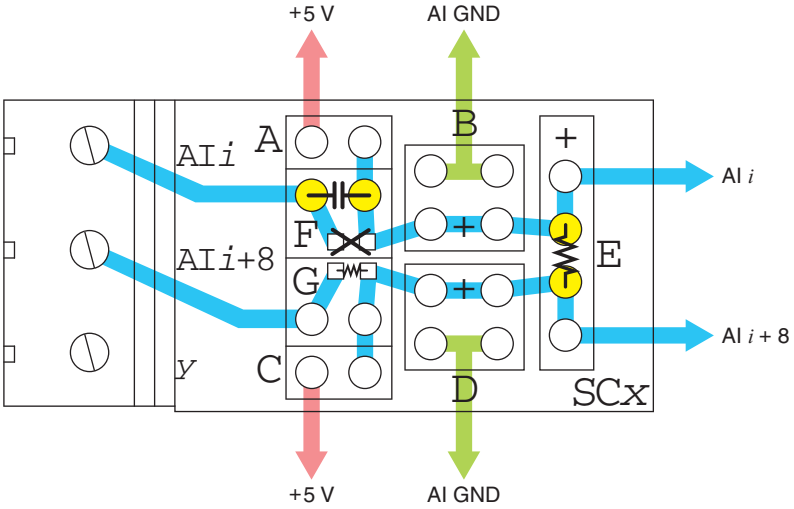
Adding Components for Highpass Filtering on Analog Input Signals

Using the circuit shown in Figure 2-27, you can use a two-component circuit to build a simple RC filter with an analog input.

- **Differential analog input highpass filter**—To build a differential highpass filter, add the resistor to position E and the capacitor to position F, as shown in Figure 2-28. Refer to Table 2-1 for component positions for all analog input channels.

  The SCB-68A ships with a surface mount 0 Ω resistor in the F position. You *must* remove the resistor to use the position.

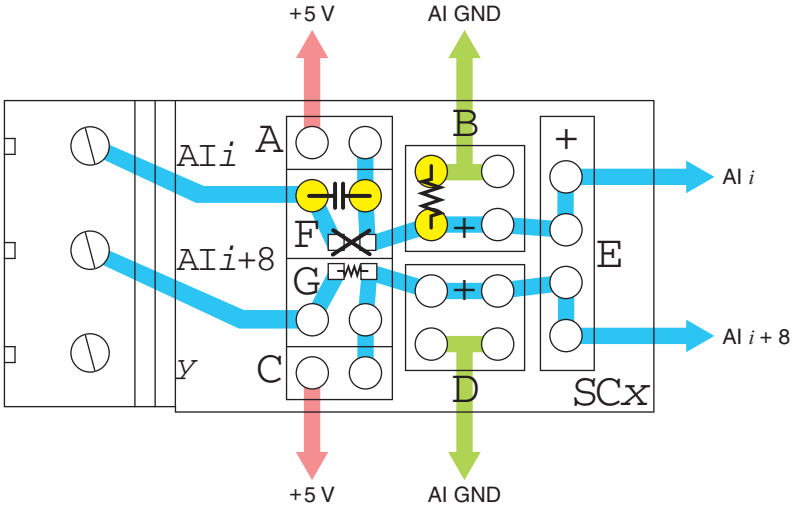
Figure 2-28. SCB-68A Circuit Diagram for Differential Analog Input Highpass Filter



- **Single-ended analog input highpass filter**—To build a single-ended highpass filter, refer to Figure 2-29. Add the resistor to position B or D, depending on the AI channel you are using. Add the capacitor to position F or G, depending on the AI channel you are using. Refer to Table 2-1 for component positions for all analog input channels.

  The SCB-68A ships with a surface mount 0 Ω resistor in the F and G positions. You *must* remove the resistor to use the position.

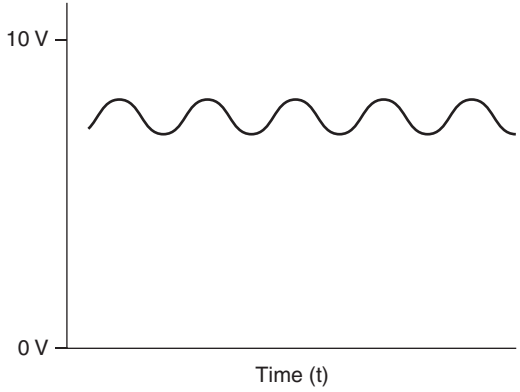
Figure 2-29. SCB-68A Circuit Diagram for Single-Ended Analog Input Highpass Filter on AI <i>



Analog Input Highpass Filtering Applications

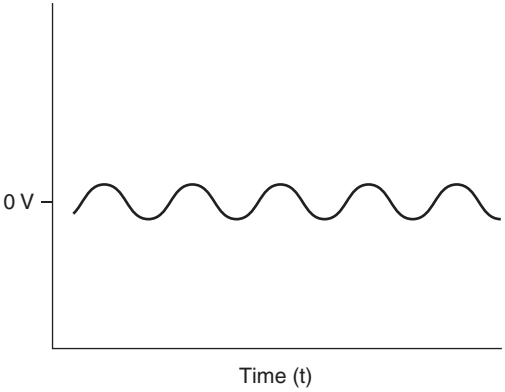
One of the most common applications for highpass filters for analog inputs is to use the filter to do AC coupling. AC coupling can be achieved by creating a highpass filter with a very low cutoff frequency. This filter allows most dynamic signals through, while it blocks any DC offsets in the signal. This can be used to increase the resolution with which you can measure a dynamic signal that is riding on top of an offset, as shown in Figure 2-30.

Figure 2-30. Signal before Passing through Filter



Without the AC coupling you would use the ±10 V range or the 0–10 V range. After passing through the filter, the dynamic portion of the signal is retained and centered around 0, as shown in Figure 2-31.

Figure 2-31. Signal after Passing through Filter



You can now reduce your range to ±1 V to increase the resolution of the measurement.

Current Input Measurement

Some DAQ devices cannot directly measure current. This section describes how to add components for measuring current up to 20 mA.

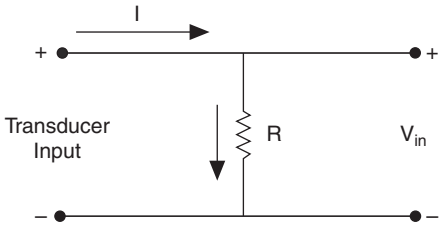
The conversion from current to voltage is based on Ohm's Law, summarized by the following equation:

$$V = I \times R$$

where V is voltage, I is current, and R is resistance.

By putting a resistor with a known value in series with the current and measuring the voltage produced across the resistor as shown in Figure 2-32, you can calculate the current flowing through the circuit.

Figure 2-32. Current-to-Voltage Electrical Circuit



The application software must linearly convert voltage back to current. The following equation demonstrates this conversion, where the resistor is the denominator and V_{in} is the input voltage into the DAQ device:

$$I = \frac{V_{in}}{R}$$

Selecting a Resistor for Current Input Measurement

For best results when measuring current, choose a resistor that has the following characteristics:

- Low wattage of approximately 0.125 W
- Precision of at least 5%
- Temperature stability
- Tolerance of 5%
- 232 Ω (suggested)
- AXL package (suggested)
- Carbon or metal film (suggested)

If you use the resistor described above, you can convert a 20 mA current to 4.64 V by setting the device range to either (–5 to +5 V) or (0 to 5 V).

Adding Components for Current Input Measurement on Analog Input Signals

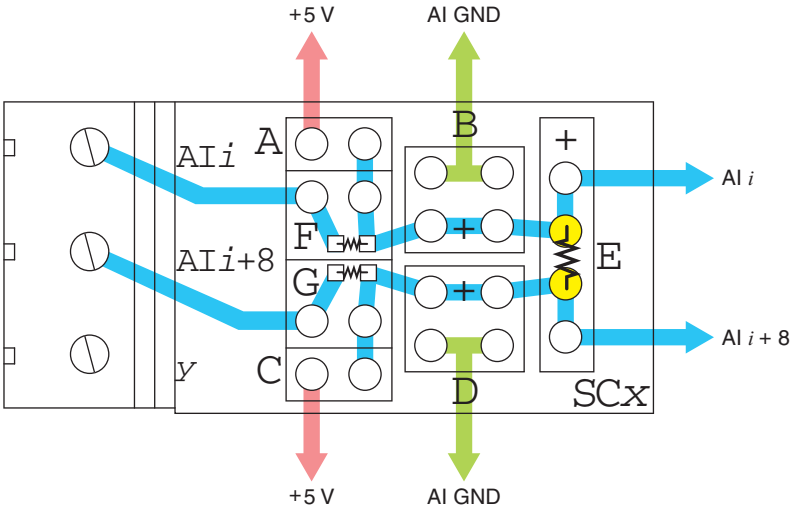
Caution Do *not* exceed ±10 V at the analog inputs. NI is *not* liable for any device damage or personal injury resulting from improper connections.

You can build a one-resistor circuit for measuring current at the single-ended or differential inputs of the SCB-68A:

- **Differential analog inputs**—To build a one-resistor circuit that measures current at the differential inputs of the SCB-68A, add the resistor to position E for each differential channel pair that is used. Leave the 0 Ω resistors in place for positions F and G. Refer to Table 2-1 for component positions for all analog input channels. Calculate the current according to the following equation:

$$I = \frac{V_m}{R_E}$$

Figure 2-33. Measuring Current with Differential Analog Inputs

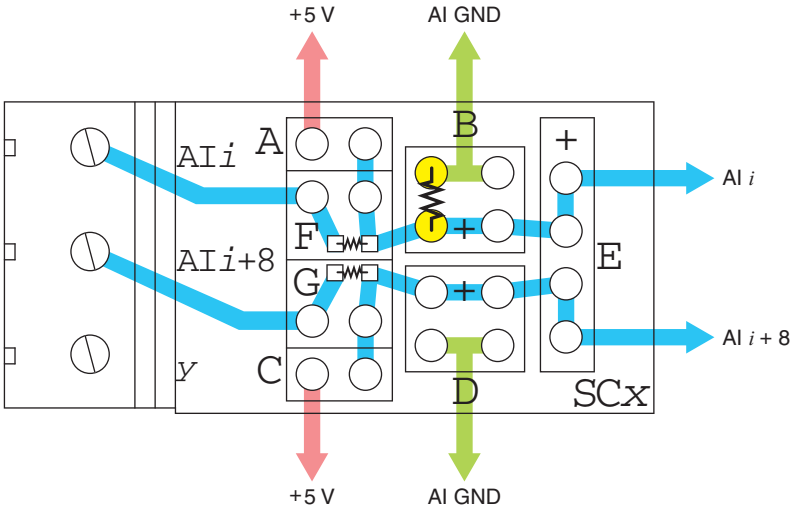


- **Single-ended analog inputs**—To build a one-resistor circuit that measures current at the single-ended analog inputs of the SCB-68A, add the resistor to position B or D, depending on the channel being used. Leave the 0 Ω resistors in place for channel positions F and G, respectively. Refer to Table 2-1 for component positions for all analog input channels. Calculate the current according to the following equation,

$$I = \frac{V_m}{R_{B \text{ or } D}}$$

where $R_{B \text{ or } D}$ is the resistance of the resistor in position B or D.

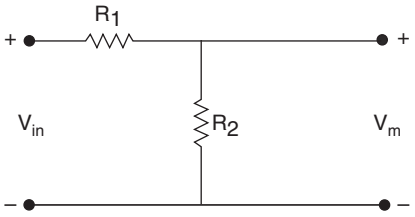
Figure 2-34. Measuring Current with Single-Ended Analog Input (AI <i>)



Attenuating Voltage

Transducers can generate more than 10 VDC per channel, but DAQ devices cannot read more than 10 VDC per input channel. Therefore, you must attenuate output signals from the transducer to fit within the DAQ device specifications. Figure 2-35 shows how to use a voltage divider to attenuate the output signal of the transducer.

Figure 2-35. Attenuating Voltage with a Voltage Divider



The voltage divider splits the input voltage (V_{in}) between two resistors (R_1 and R_2), causing the voltage on each resistor to be noticeably lower than V_{in}. Use Equation 2-6 to determine the V_m that the DAQ device measures:

$$V_m = V_{in}\left(\frac{R_2}{R_1 + R_2}\right) \quad (2\text{-}6)$$

Use Equation 2-7 to determine the overall gain of a voltage divider circuit:

$$G = \frac{V_m}{V_{in}} = \frac{R_2}{R_1 + R_2} \quad (2\text{-}7)$$

The accuracy of Equation 2-7 depends on the tolerances of the resistors that you use.

Caution The SCB-68A is *not* designed for any input voltages >30 V_{rms}/42 V_{pk}/60 VDC, even if a user-installed voltage divider reduces the voltage to within the input range of the DAQ device. Input voltages >30 V_{rms}/42 V_{pk}/60 VDC can damage the SCB-68A, any devices connected to it, and the host computer. Overvoltage can also cause an electric shock hazard for the operator.

Selecting Components for Attenuating Voltage

To set up the resistors, complete the following steps.

1. Select the value for R_2 (10 kΩ is recommended).
2. Use Equation 2-6 to calculate the value for R_1.

   Base the R_1 calculation on the following values:

   - Maximum V_{in} you expect from the transducer
   - Maximum voltage (<10 VDC) that you want to input to the DAQ device

Accuracy Considerations for Attenuating Voltage

For best results when attenuating voltage, choose a resistor that has the following characteristics:

- Low wattage of approximately 0.125 W
- Precision of at least 5%
- Temperature stable
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

Verify that R_1 and R_2 drift together with respect to temperature; otherwise, the system may consistently read incorrect values.

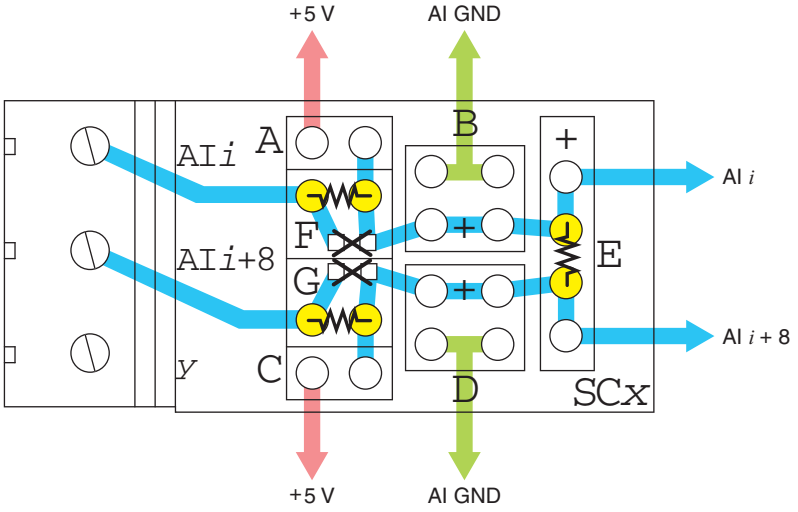
Adding Components for Attenuating Voltage on Analog Input Signals

You can build a two- or three-resistor circuit for attenuating voltages at the single-ended analog inputs and differential analog inputs of the SCB-68A:

- **Differential analog input attenuators**—To build a three-resistor circuit for attenuating voltages at the differential analog inputs of the SCB-68A, refer to Figure 2-36. Refer to Table 2-1 for component positions for all analog input channels.

  The SCB-68A ships with a surface mount 0 Ω resistor in the F and G positions. You *must* remove the resistors to use these positions.

  Figure 2-36. SCB-68A Circuit Diagram for Differential Analog Input Attenuation



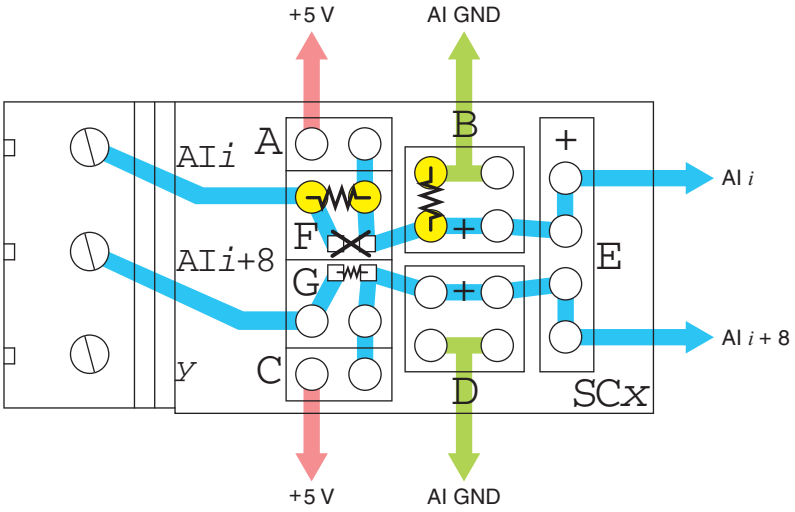
  Install resistors in positions E, F, and G of the chosen differential channel pair. Use the following equation to determine the gain of the circuit:

$$G = \frac{R_E}{(R_E + R_F + R_G)}$$

- **Single-ended analog input attenuators**—To build a two-resistor circuit for attenuating voltages at the single-ended analog inputs of the SCB-68A, refer to Figure 2-37. Refer to Table 2-1 for component positions for all analog input channels.

  The SCB-68A ships with a surface mount 0 Ω resistor in the F and G positions. You *must* remove the resistor to use the position.

Figure 2-37. SCB-68A Circuit Diagram for Single-Ended Analog Input Attenuation on AI <i>



Install resistors in positions B and F, or positions D and G, depending on the channel you are using on the SCB-68A. Use the following equation to calculate the gain of the circuit:

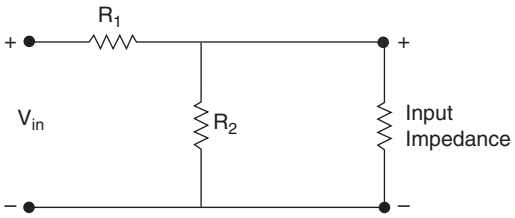
$$G = \frac{R_{B\ \text{or}\ D}}{(R_{B\ \text{or}\ D} + R_{F\ \text{or}\ G})}$$

where $R_{B\ \text{or}\ D}$ is the resistance of the resistor in position B or D, and $R_{F\ \text{or}\ G}$ is the resistance of the resistor in position F or G.

Analog Input Voltage Dividers

When calculating the values for R_1 and R_2, consider the input impedance value from the point of view of V_{in}, as shown in Figure 2-38.

Figure 2-38. Input Impedance Electrical Circuit



The following equation shows the relationship among all of the resistor values:

$$Z_{in} = R_1 + \frac{(R_2 \times Input\ Impedance)}{(R_2 + Input\ Impedance)}$$

Z_{in} is the new input impedance. Refer to the device specifications for the input impedance of your device.

3

Analog Output Waveforms

This chapter covers many topics associated with generating analog output waveforms, including how to condition signals by adding components to the open component locations of the SCB-68A for lowpass filtering and attenuating voltage applications.

Caution Add components at your own risk. NI is *not* liable for any damage resulting from improperly added components.

In addition to the applications described in this chapter, you can build many other types of signal conditioning using the component pads and the general-purpose breadboard area of the SCB-68A. Refer to the *Soldering and Desoldering Components on the SCB-68A* section of Chapter 1, *Getting Started with the SCB-68A*, for more information about adding components and for soldering and desoldering instructions.

After building one of the applications described in this chapter or your custom circuitry, refer to the *Setting up the SCB-68A* section of Chapter 1, *Getting Started with the SCB-68A*, for instructions about how to configure the SCB-68A in Measurement & Automation Explorer (MAX). You can create virtual channels in MAX to create a custom scale or map your voltage ranges to the type of transducer that you use.

Analog Output Channel Pad Configuration

When you use the SCB-68A with a 68-pin or 100-pin MIO DAQ device, you can use the component pads on the SCB-68A to condition two AO channels. Figure 3-1 shows the circuitry for both analog output channels on the SCB-68A.

Figure 3-1. Analog Output Circuitry

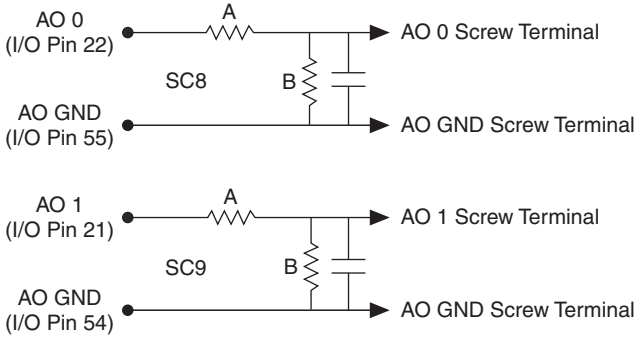


Figure 3-2 illustrates the generic AO channel pad configuration.

Figure 3-2. Analog Output Channel Pad Configuration

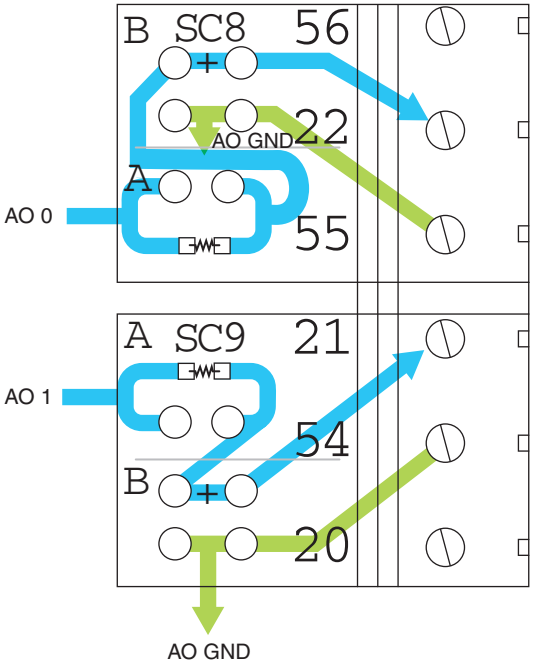


Table 3-1 correlates the component labels of the SCB-68A to component locations A and B for analog output channels 0 and 1.

Table 3-1. Analog Output Channels Component Locations

Channel	Positions A* and B†
AO 0	SC8
AO 1	SC9

* A position contains a surface mount 0 Ω resistor; you *must* remove the resistor to use the position. If you remove your custom components from the A position, you *must* reinstall a 0 Ω resistor.
† B position contains through hole pads that can be used for two components to be connected in parallel.

Lowpass Filtering

Lowpass filters highly or completely attenuate signals with frequencies above the cut-off frequency, or high-frequency stopband signals. Lowpass filters do not attenuate signals with frequencies below the cut-off frequency, or low-frequency passband signals. Ideally, lowpass

filters have a phase shift that is linear with respect to frequency. This linear phase shift delays signal components of all frequencies by a constant time, independent of frequency, thereby preserving the overall shape of the signal.

In practice, lowpass filters subject input signals to a mathematical transfer function that approximates the characteristics of an ideal filter. By analyzing the Bode Plot, or the plot that represents the transfer function, you can determine the filter characteristics.

Figures 3-3 and 3-4 show the Bode Plots for the ideal filter and the real filter, respectively, and indicate the attenuation of each transfer function.

Figure 3-3. Transfer Function Attenuation for an Ideal Filter

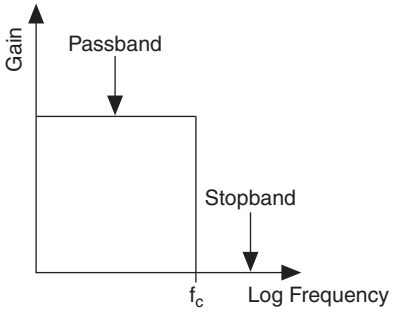
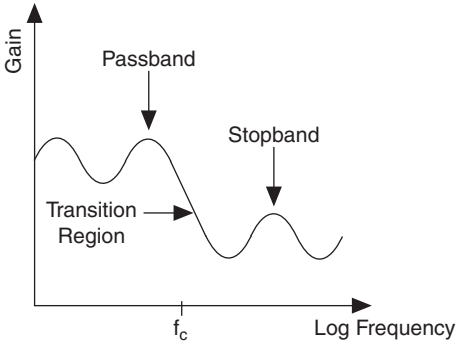


Figure 3-4. Transfer Function Attenuation for a Real Filter

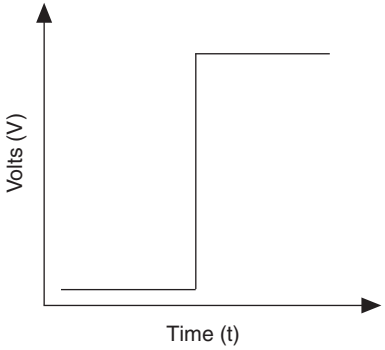


The cut-off frequency, f_c, is defined as the frequency beyond which the gain drops 3 dB. Figure 3-3 shows how an ideal filter causes the gain to drop to zero for all frequencies greater than f_c. Thus, f_c does not pass through the filter to its output. Instead of having a gain of absolute zero for frequencies greater than f_c, the real filter has a transition region between the passband and the stopband, a ripple in the passband, and a stopband with a finite attenuation gain.

Real filters have some nonlinearity in their phase response, causing signals at higher frequencies to be delayed longer than signals at lower frequencies and resulting in an overall shape distortion

of the signal. For example, when the square wave, shown in Figure 3-5, enters a filter, an ideal filter smooths the edges of the input, whereas a real filter causes some ringing in the signal as the higher frequency components of the signal are delayed.

Figure 3-5. Square Wave Input Signal



Figures 3-6 and 3-7 show the difference in response to a square wave between an ideal and a real filter, respectively.

Figure 3-6. Response of an Ideal Filter to a Square Wave Input Signal

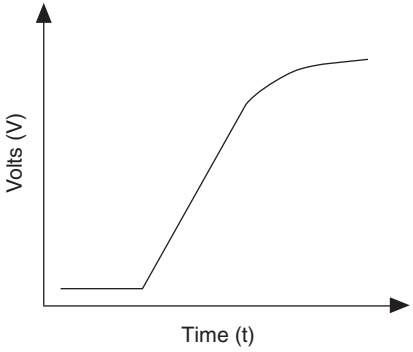
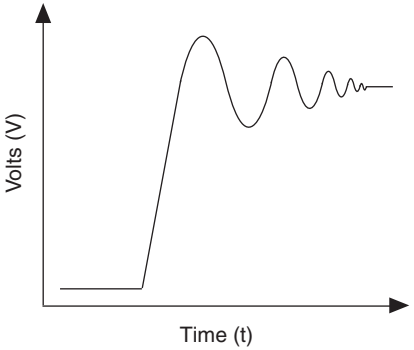


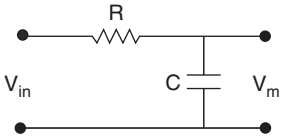
Figure 3-7. Response of a Real Filter to a Square Wave Input Signal



One-Pole Lowpass RC Filter

Figure 3-8 shows the transfer function of a simple series circuit consisting of a resistor (R) and capacitor (C) when the voltage across R is assumed to be the output voltage (V_m).

Figure 3-8. Simple RC Lowpass Filter



The transfer function is a mathematical representation of a one-pole lowpass filter, with a time constant of:

$$\frac{1}{2\pi RC}$$

Use Equation 3-1 to design a lowpass filter for a simple resistor and capacitor circuit, where the values of the resistor and capacitor alone determine f_c:

$$T(s) = \frac{G}{1 + (2\pi RC)s} \tag{3-1}$$

where G is the DC gain and s represents the frequency domain.

Selecting Components for Lowpass Filtering

To determine the value of the components in the circuit, fix R (10 kΩ is reasonable) and isolate C from Equation 3-1 as follows:

$$C = \frac{1}{2\pi R f_c} \tag{3-2}$$

The cut-off frequency in Equation 3-2 is f_c.

For best results, choose a resistor that has the following characteristics:

- Low wattage of approximately 0.125 W
- Precision of at least 5%
- Temperature stability
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

Choose a capacitor that has the following suggested characteristics:

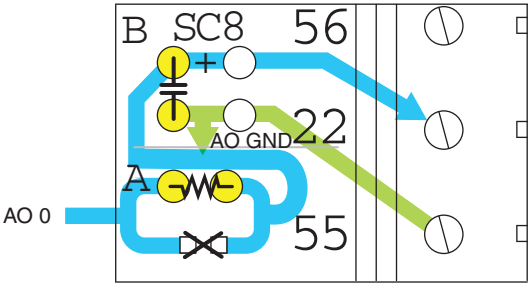
- AXL or RDL package
- Tolerance of 20%
- Maximum voltage of at least 25 V

Adding Components for Lowpass Smoothing Filters on Analog Output Signals

Using the circuit shown in Figure 3-8, you can use a two-component circuit to build a simple RC filter with analog output. To build a lowpass filter for analog output, put a resistor in position A and a capacitor in position B, as shown in Figure 3-9.

The SCB-68A ships with a surface mount 0 Ω resistor in the A position. You *must* remove the resistor to use the position. Refer to Table 3-1 for component positions for both analog output channels.

Figure 3-9. SCB-68A Circuit Diagram for Analog Output Lowpass Filter

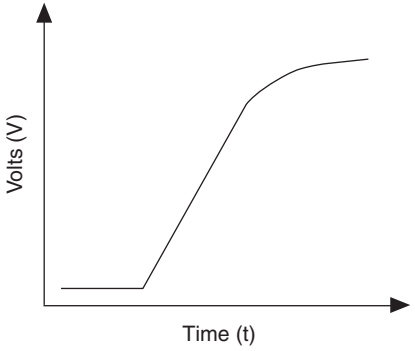


Analog Output Lowpass Filtering Applications

The following applications benefit from lowpass filtering:

- **Protection for external circuitry**—Lowpass filters can smooth stairstep-like curves on AO signals. If the curves are not smoothed, the AO signals can be a hazard for some external circuitry connected to it. Figure 3-10 shows the output of a lowpass filter when a stairstep-like signal is the input.

Figure 3-10. Lowpass Filtering of AO Signals

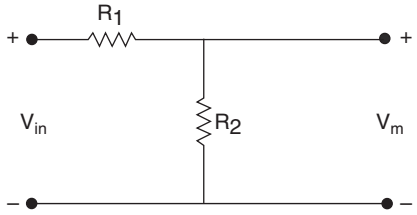


- **Deglitching analog output signals**—Lowpass filters can be used to decrease glitches from an analog output signal. When you use a DAC to generate a waveform, you may observe glitches on the output signal. These glitches are normal; when a DAC switches from one voltage to another, it produces glitches due to released charges. The largest glitches occur when the most significant bit of the DAC code changes. You can build a lowpass deglitching filter to remove some of these glitches, depending on the frequency and nature of the output signal. To select a cutoff frequency for the deglitching filter, refer to your DAQ device documentation for the maximum glitch duration.

Attenuating Voltage

Transducers can generate more than 10 VDC per channel, but DAQ devices cannot read more than 10 VDC per input channel. Therefore, you must attenuate output signals from the transducer to fit within the DAQ device specifications. Figure 3-11 shows how to use a voltage divider to attenuate the output signal of the transducer.

Figure 3-11. Attenuating Voltage with a Voltage Divider



The voltage divider splits the input voltage (V_{in}) between two resistors (R_1 and R_2), causing the voltage on each resistor to be noticeably lower than V_{in}. Use Equation 3-3 to determine the V_m that the DAQ device measures:

$$V_m = V_{in}\left(\frac{R_2}{R_1 + R_2}\right) \tag{3-3}$$

Use Equation 3-4 to determine the overall gain of a voltage divider circuit:

$$G = \frac{V_m}{V_{in}} = \frac{R_2}{R_1 + R_2} \tag{3-4}$$

The accuracy of Equation 3-4 depends on the tolerances of the resistors that you use.

Caution The SCB-68A is *not* designed for any input voltages >30 V_{rms}/42 V_{pk}/60 VDC, even if a user-installed voltage divider reduces the voltage to within the input range of the DAQ device. Input voltages >30 V_{rms}/42 V_{pk}/60 VDC can damage the SCB-68A, any devices connected to it, and the host computer. Overvoltage can also cause an electric shock hazard for the operator.

Selecting Components for Attenuating Voltage

To set up the resistors, complete the following steps.

1. Select the value for R_2 (10 kΩ is recommended).
2. Use Equation 3-3 to calculate the value for R_1.

   Base the R_1 calculation on the following values:

   - Maximum V_{in} you expect from the transducer
   - Maximum voltage (<10 VDC) that you want to input to the DAQ device

Accuracy Considerations for Attenuating Voltage

For best results when attenuating voltage, choose a resistor that has the following characteristics:

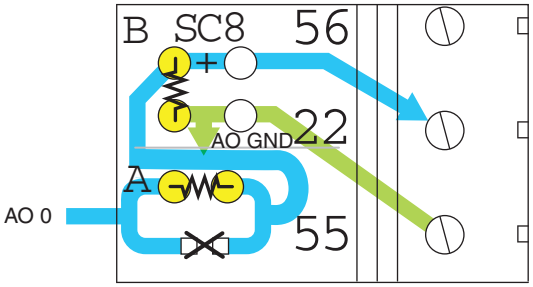
- Low wattage of approximately 0.125 W
- Precision of at least 5%
- Temperature stable
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

Verify that R_1 and R_2 drift together with respect to temperature; otherwise, the system may consistently read incorrect values.

Adding Components for Attenuating Voltage on Analog Output Signals

To build a two-resistor circuit for attenuating voltages at the AO 0 and AO 1 pins on the SCB-68A, refer to the pad positions in Figure 3-12. The SCB-68A ships with a surface mount 0 Ω resistor in the A position. You *must* remove the resistor to use the position. Refer to Table 3-1 for component positions for both analog output channels.

Figure 3-12. SCB-68A Circuit Diagram for Analog Output Attenuation



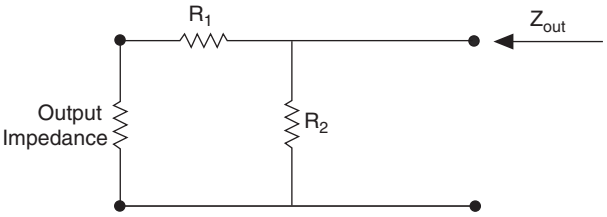
Install resistors in positions A and B and determine the gain according to Equation 3-5:

$$G = \frac{R_B}{(R_B + R_A)} \tag{3-5}$$

Analog Output Voltage Dividers

When you use the circuit shown in Figure 3-11 for analog output, the output impedance changes. Thus, you must choose the values for R_1 and R_2 so that the final output impedance value is as low as possible. Refer to the device specifications for the output impedance for your device. Figure 3-13 shows the electrical circuit you use to calculate the output impedance.

Figure 3-13. Electrical Circuit for Determining Output Impedance



The following equation shows the relationship between R_1, R_2, and Z_{out}, where Z_{out} is the old output impedance and Z_{out2} is the new output impedance:

$$Z_{out2} = \frac{(Z_{out} + R_1) \times R_2}{Z_{out} + R_1 + R_2}$$

4

PFI 0 and Digital Input Measurements

This chapter covers many topics associated with taking digital input and PFI 0 measurements and generating PFI 0 signals, including how to condition signals by adding components to the open component locations of the SCB-68A for lowpass filtering and attenuating voltage applications.

Caution Add components at your own risk. NI is *not* liable for any damage resulting from improperly added components.

In addition to the applications described in this chapter, you can build many other types of signal conditioning using the component pads and the general-purpose breadboard area of the SCB-68A. Refer to the *Soldering and Desoldering Components on the SCB-68A* section of Chapter 1, *Getting Started with the SCB-68A*, for more information about adding components and for soldering and desoldering instructions.

After building one of the applications described in this chapter or your custom circuitry, refer to the *Setting up the SCB-68A* section of Chapter 1, *Getting Started with the SCB-68A*, for instructions about how to configure the SCB-68A in Measurement & Automation Explorer (MAX). You can create virtual channels in MAX to create a custom scale or map your voltage ranges to the type of transducer that you use.

PFI 0 Channel Pad Configuration

When you use the SCB-68A with a 68-pin or 100-pin MIO DAQ device, you can use the SC10 component pads on the SCB-68A to condition PFI 0. Figure 4-1 shows the digital trigger circuitry for PFI 0.

Figure 4-1. Digital Trigger Circuitry

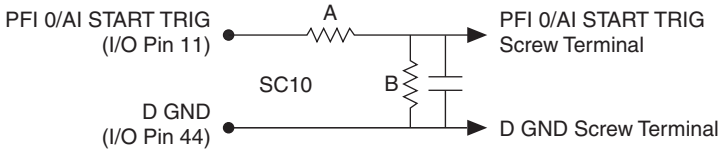
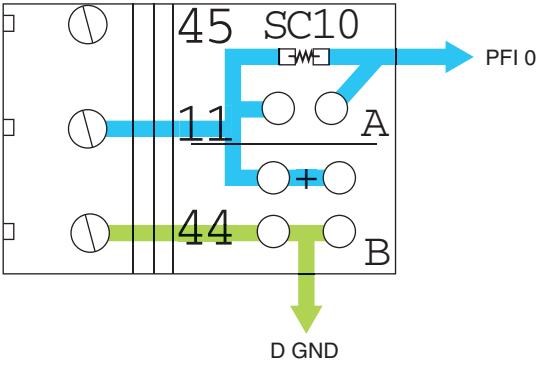


Figure 4-2 shows the digital input channel configuration for PFI 0.

Figure 4-2. Digital Input Channel Pad Configuration



The SCB-68A ships with a surface mount 0 Ω resistor in the A position. You must remove the resistor to use the position. If you remove your custom components from the A position, you must reinstall a 0 Ω resistor. The B position contains through hole pads that can be used for two components to be connected in parallel.

Lowpass Filtering

Lowpass filters highly or completely attenuate signals with frequencies above the cut-off frequency, or high-frequency stopband signals. Lowpass filters do not attenuate signals with frequencies below the cut-off frequency, or low-frequency passband signals. Ideally, lowpass filters have a phase shift that is linear with respect to frequency. This linear phase shift delays signal components of all frequencies by a constant time, independent of frequency, thereby preserving the overall shape of the signal.

In practice, lowpass filters subject input signals to a mathematical transfer function that approximates the characteristics of an ideal filter. By analyzing the Bode Plot, or the plot that represents the transfer function, you can determine the filter characteristics.

Figures 4-3 and 4-4 show the Bode Plots for the ideal filter and the real filter, respectively, and indicate the attenuation of each transfer function.

Figure 4-3. Transfer Function Attenuation for an Ideal Filter

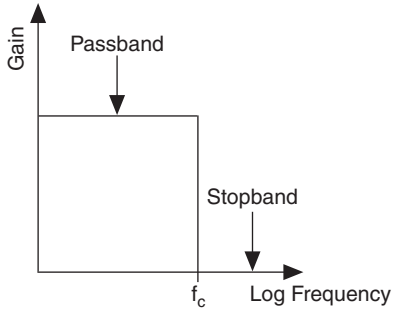
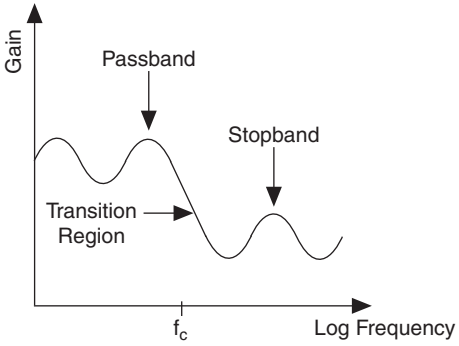


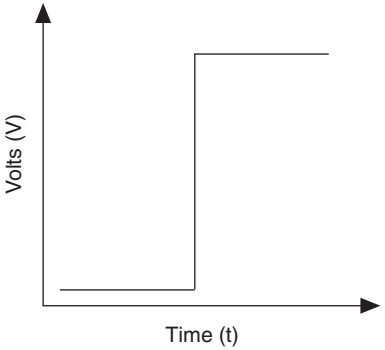
Figure 4-4. Transfer Function Attenuation for a Real Filter



The cut-off frequency, f_c, is defined as the frequency beyond which the gain drops 3 dB. Figure 4-3 shows how an ideal filter causes the gain to drop to zero for all frequencies greater than f_c. Thus, f_c does not pass through the filter to its output. Instead of having a gain of absolute zero for frequencies greater than f_c, the real filter has a transition region between the passband and the stopband, a ripple in the passband, and a stopband with a finite attenuation gain.

Real filters have some nonlinearity in their phase response, causing signals at higher frequencies to be delayed longer than signals at lower frequencies and resulting in an overall shape distortion of the signal. For example, when the square wave, shown in Figure 4-5, enters a filter, an ideal filter smooths the edges of the input, whereas a real filter causes some ringing in the signal as the higher frequency components of the signal are delayed.

Figure 4-5. Square Wave Input Signal



Figures 4-6 and 4-7 show the difference in response to a square wave between an ideal and a real filter, respectively.

Figure 4-6. Response of an Ideal Filter to a Square Wave Input Signal

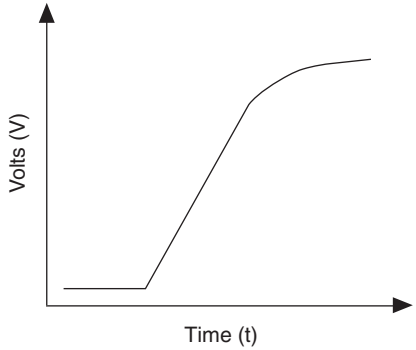
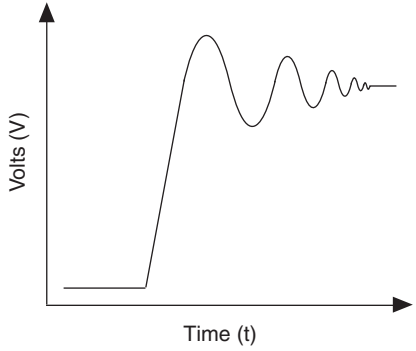


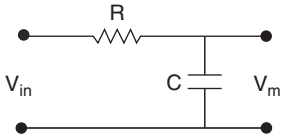
Figure 4-7. Response of a Real Filter to a Square Wave Input Signal



One-Pole Lowpass RC Filter

Figure 4-8 shows the transfer function of a simple series circuit consisting of a resistor (R) and capacitor (C) when the voltage across R is assumed to be the output voltage (V_m).

Figure 4-8. Simple RC Lowpass Filter



The transfer function is a mathematical representation of a one-pole lowpass filter, with a time constant of:

$$\frac{1}{2\pi RC}$$

Use Equation 4-1 to design a lowpass filter for a simple resistor and capacitor circuit, where the values of the resistor and capacitor alone determine f_c:

$$T(s) = \frac{G}{1 + (2\pi RC)s} \tag{4-1}$$

where G is the DC gain and s represents the frequency domain.

Selecting Components for Lowpass Filtering

To determine the value of the components in the circuit, fix R (10 kΩ is reasonable) and isolate C from Equation 4-1 as follows:

$$C = \frac{1}{2\pi R f_c} \tag{4-2}$$

The cut-off frequency in Equation 4-2 is f_c.

For best results, choose a resistor that has the following characteristics:

- Low wattage of approximately 0.125 W
- Precision of at least 5%
- Temperature stability
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

Choose a capacitor that has the following suggested characteristics:

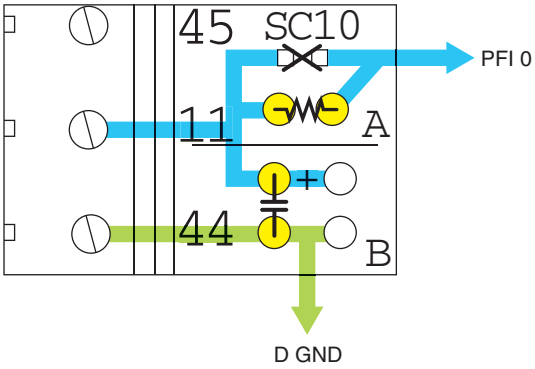
- AXL or RDL package
- Tolerance of 20%
- Maximum voltage of at least 25 V

Adding Components for Lowpass Digital Filtering on Digital Trigger Input Signals

Using the circuit shown in Figure 4-8, you can use a two-component circuit to build a simple RC filter with digital input. For PFI 0, add the resistor to position A and the capacitor to position B. Refer to Figure 4-9 for the digital input channel pad configuration.

The SCB-68A ships with a surface mount 0 Ω resistor in the A position. You *must* remove the resistor to use the position.

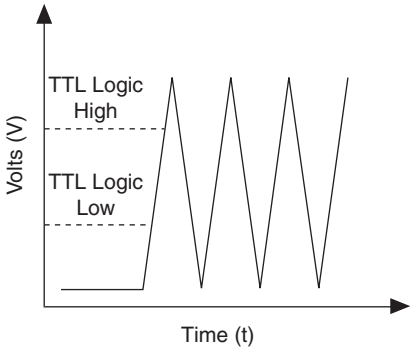
Figure 4-9. SCB-68A Circuit Diagram for Digital Trigger Input Lowpass Filter



PFI 0 Lowpass Filtering Applications

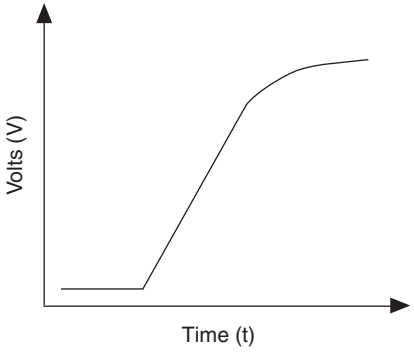
Lowpass filters can function as debouncing filters to smooth noise on digital trigger input signals, thus enabling the trigger-detection circuitry of the DAQ device to understand the signal as a valid digital trigger.

Figure 4-10. Digital Trigger Input Signal with a High-Frequency Component



Apply a lowpass filter to the signal to remove the high-frequency component for a cleaner digital signal, as Figure 4-11 shows.

Figure 4-11. Lowpass Filtering of Digital Trigger Input Signals

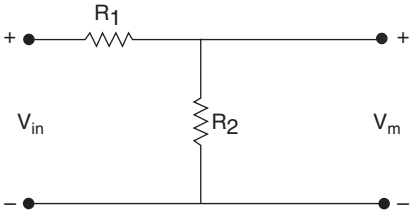


Note Due to the filter order, the digital trigger input signal is delayed for a specific amount of time depending on the filter you use before the DAQ device senses the signal at the trigger input.

Attenuating Voltage

Transducers can generate more than 10 VDC per channel, but DAQ devices cannot read more than 10 VDC per input channel. Therefore, you must attenuate output signals from the transducer to fit within the DAQ device specifications. Figure 4-12 shows how to use a voltage divider to attenuate the output signal of the transducer.

Figure 4-12. Attenuating Voltage with a Voltage Divider



The voltage divider splits the input voltage (V_{in}) between two resistors (R_1 and R_2), causing the voltage on each resistor to be noticeably lower than V_{in}. Use Equation 4-3 to determine the V_m that the DAQ device measures:

$$V_m = V_{in}\left(\frac{R_2}{R_1 + R_2}\right) \tag{4-3}$$

Use Equation 4-4 to determine the overall gain of a voltage divider circuit:

$$G = \frac{V_m}{V_{in}} = \frac{R_2}{R_1 + R_2} \tag{4-4}$$

The accuracy of Equation 4-4 depends on the tolerances of the resistors that you use.

Caution The SCB-68A is *not* designed for any input voltages >30 V_{rms}/42 V_{pk}/60 VDC, even if a user-installed voltage divider reduces the voltage to within the input range of the DAQ device. Input voltages >30 V_{rms}/42 V_{pk}/60 VDC can damage the SCB-68A, any devices connected to it, and the host computer. Overvoltage can also cause an electric shock hazard for the operator.

Selecting Components for Attenuating Voltage

To set up the resistors, complete the following steps.

1. Select the value for R_2 (10 kΩ is recommended).
2. Use Equation 4-3 to calculate the value for R_1.

   Base the R_1 calculation on the following values:

   - Maximum V_{in} you expect from the transducer
   - Maximum voltage (<10 VDC) that you want to input to the DAQ device

Accuracy Considerations for Attenuating Voltage

For best results when attenuating voltage, choose a resistor that has the following characteristics:

- Low wattage of approximately 0.125 W
- Precision of at least 5%
- Temperature stable
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

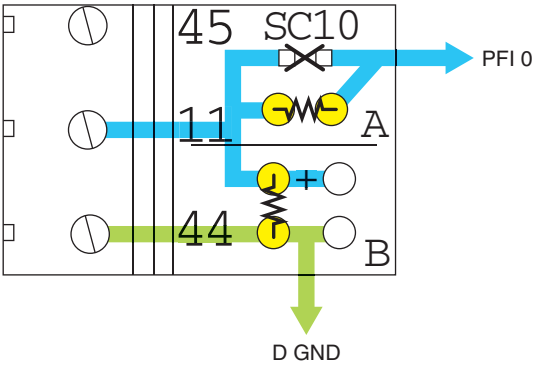
Verify that R_1 and R_2 drift together with respect to temperature; otherwise, the system may consistently read incorrect values.

Adding Components for Attenuating Voltage on Digital Inputs

To build a two-resistor circuit for attenuating voltages at the PFI 0 pin on the SCB-68A, refer to the pad positions in Figure 4-13.

The SCB-68A ships with a surface mount 0 Ω resistor in the SC10 position. You *must* remove the resistor to use the position.

Figure 4-13. SCB-68A Circuit Diagram for Digital Input Attenuation



Use positions A and B for PFI 0, and determine the gain according to Equation 4-5:

$$G = \frac{B}{(B + A)} \tag{4-5}$$

Digital Input Voltage Dividers

If you use the V_{in} voltage of Figure 4-12 to feed TTL signals, you must calculate V_{in} so that the voltage drop on R_2 does not exceed 5 V.

Caution A voltage drop exceeding 5 V on R_2 can damage the internal circuitry of the DAQ device. NI is *not* liable for any device damage resulting from improper use of the SCB-68A and the DAQ device.

5

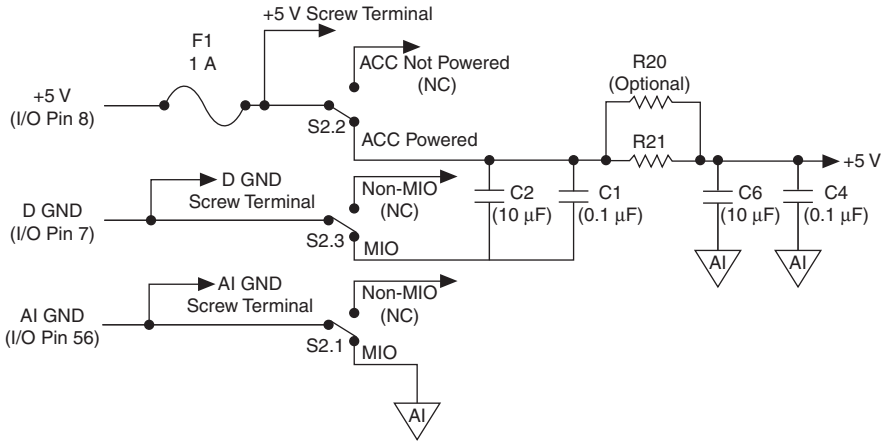
Fuse and Power Information

Refer to the *Soldering and Desoldering Components on the SCB-68A* section of Chapter 1, *Getting Started with the SCB-68A*, for more information about adding components and for soldering and desoldering instructions.

Power Supply Circuitry

Figure 5-1 shows the power supply circuitry on the SCB-68A.

Figure 5-1. +5 V Power Supply



Fuse

Some DAQ devices provide +5 V power on pin 8 and pin 14. Pin 8 from the DAQ device is protected by a 1 A self-resetting fuse, shown in Figure 1-2, *SCB-68A Printed Circuit Board Diagram*. Shorting pin 8 to ground trips the fuse on the SCB-68A. Pin 14 is *not* fuse-protected on the SCB-68A. Shorting pin 14 will cause the fuse on the DAQ device to open.

If the SCB-68A does not work when you power on the DAQ device, check the switch settings on the SCB-68A and the output fuse (if any) on the DAQ device.

Adding Power Filters

Caution If you are modifying the power filter, do *not* draw ≥100 mA from the +5 V power line.

A 470 Ω series resistor (R21) is part of the power filter for the +5 V power on the SCB-68A. Due to the nature of the filter design, as the filtered +5 V is loaded, the voltage supplied to the SCB-68A circuitry and screw terminal 8 decreases. Pad R20, shown in Figure 1-2, *SCB-68A Printed Circuit Board Diagram*, is in parallel with R21. You can install a resistor, if needed, to decrease the overall resistance used in the filter and reduce the loading effect. However, completely shorting R20 bypasses the filter while capacitively coupling D GND to AI GND and AO GND and is not recommended.

Caution Add components at your own risk. NI is *not* liable for any damage resulting from improperly added components.

Caution NI is *not* liable for any device damage resulting from improper use of the SCB-68A and the DAQ device.

A

Specifications

This appendix lists the SCB-68A specifications. These specifications are typical at 25 °C unless otherwise noted.

Caution Do *not* connect hazardous voltages (>30 V_{rms}/42 V_{pk}/60 VDC) to the SCB-68A.

Temperature Sensor

Accuracy ..... ±1.0 °C over a 0 to 70 °C range

Power Requirement

Power consumption (at +5 VDC, ±5%)

Typical ..... 1 mA with no signal conditioning installed

Maximum ..... 800 mA from host computer

Note The power specifications pertain to the power supply of the host computer when using internal power or to the external supply connected at the +5 V screw terminal when using external power. The maximum power consumption of the SCB-68A is a function of the signal conditioning components installed and any circuits constructed on the general-purpose breadboard area. If the SCB-68A is powered from the host computer, the maximum +5 V current draw, which is limited by the fuse, is 800 mA.

Fuse

Rating ..... 1.10 A, 8 VDC SMT PTC
Fuse is not user-replaceable

Physical Characteristics

Dimensions (including feet) ..... 14.7 × 14.7 × 3.0 cm (5.8 × 5.8 × 1.2 in.)

Weight ..... 644 g (1 lb 7 oz)

I/O connector ..... One 68-pin male SCSI connector

Screw terminals ..... 68, all I/O signals are available at screw terminals

Wire gauge ..... 14–30 AWG

Torque ..... 0.5–0.6 N · m (4.4–5.3 in. · lb)

Through hole pads ..... 0.8 to 0.9 mm (in diameter)

Safety Voltages

Connect only voltages that are no greater than 30 V_{rms}/42 V_{pk}/60 VDC.

Environmental

Temperature

- Operating ..... 0 to 70 °C
- Storage ..... –20 to 70 °C

Relative humidity

- Operating ..... 5 to 90% RH, noncondensing
- Storage ..... 5 to 90% RH, noncondensing

Pollution Degree 2

Maximum altitude ..... 2,000 m

Indoor use only.

Safety

This product meets the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, and additional information, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit ni.com/certification, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

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B

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- **Calibration Certificate**—If your product supports calibration, you can obtain the calibration certificate for your product at ni.com/calibration.

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